

SHRI BRAHMAGUPTA VIRACITA

BRĀHMA-SPHUṬA SIDDHĀNTA

WITH

Vāsanā, Vijñāna and Hindi
Commentaries

Vol. I

FOREWORD

By

DR. SAMPURNANANAD

Governor-Rajasthan

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Introduction by

Dr. Satya Prakash D.Sc.



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Dedicated to
Shri S. K. Patil
Union Minister for Railways

श्रीब्रह्मगुप्ताचार्य-विरचित

ब्राह्मस्फटसिद्धान्तः

(संस्कृत-हिन्दी-भाषायां वासनाविज्ञानभाष्याभ्यां समलंकृतः सोपपत्तिकः)

प्रथमो भागः

प्राक्कथन :

डा० सम्पूर्णानन्द-राज्यपाल-राजस्थान

प्रधानसम्पादक :

आचार्यवर पंडित रामस्वरूप शर्मा

(सञ्चालक-इण्डियन इंस्टीट्यूट आफ़् ऐस्ट्रानौमिकल एण्ड संस्कृत रिसर्च)

प्रकाशक :

इण्डियन इंस्टीट्यूट आफ़् ऐस्ट्रानौमिकल एण्ड संस्कृत रिसर्च
२२३६, गुरुद्वारा रोड, करौलबाग, न्यू देहली-५.

प्रकाशक—

इंडियन इंस्टीट्यूट आफ़ ऐस्ट्रानॉमिकल
एण्ड संस्कृत रिसर्च
२२३६, गुह्यद्वारा रोड, करौल बाग़,
नई दिल्ली-५ (भारत)

①

भारत सरकार के शिक्षा मन्त्रालय द्वारा
प्रदत्त अनुदान से प्रकाशित ।

②

सम्पादक मण्डल—

श्री रामस्वरूप शर्मा सञ्चालक

प्रधान सम्पादक

डा० सत्यप्रकाश डी० एस-सी०

प्रस्तावना-लेखक

श्री मुकुन्दमिश्र ज्योतिषाचार्य

श्री विश्वनाथ झा ज्योतिषाचार्य

श्री दयाशंकर दीक्षित ज्योतिषाचार्य

श्री ओदत्त शर्मा शास्त्री

एम. ए., एम. ओ. एल.

③

प्रथम संस्करण

१९६६

④

मूल्य रु० ८०.००

⑤

मुद्रक :

पद्म श्री प्रकाशन एण्ड प्रिण्टर्स

१२ चमेलियन रोड,

दिल्ली ।

समर्पण :

श्रीयुत एस० के० पाटिल
यूनियन मिनिस्टर फ़ार रेल्वेज़
को
सादर समर्पित

Foreword

The Indian Institute of Astronomical & Sanskrit Research has done a very useful piece of work by publishing the *Brāhma Sphuṭa Siddhānta*. This is an original work on Astronomy written about twelve hundred years ago. Mainly devoting himself to Astronomy as was natural, the author, Brahma Gupta, has also given considerable space to such branches of Mathematics as in his opinion are particularly applicable to Astronomy. Brahma Gupta is not a mere theoriser. His work bears ample evidence of close observation of astronomical phenomena, though he did not have at his disposal any large and well equipped Vedhālaya or Observatory. He has had to find fault with some of his predecessors. The main reason for his criticism was as stated by him :

ब्रह्मोक्तं ग्रहगणितं महता कालेन यत् श्लथीभूतम् ।

अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन ॥

The creator Brahma himself had given certain calculations in his book namely *Brahma Siddhānta*. But in the course of many years these calculations have been found to have become inaccurate. Of course, in referring to calculations, the author is referring to the bases of these calculations, the main data of astronomy. The excellent and fairly exhaustive introduction by Dr. Satya Parkash is of very great help in understanding the book because it brings out clearly the various points on which Brahma Gupta has laid stress, particularly those on which he differs from other great astronomers.

A great controversy still rages between two schools of Indian astronomers which for want of better names may be called the schools of Arya Bhata and Brahma Gupta. Some years ago the Indian Institute of Astronomical & Sanskrit Research published the *Vateshwar Siddhānta* which is supposed to be associated with the Arya Bhata School. It is therefore, in the fitness of things that it should now publish the present standard volume of the other school.

To my mind the Publication of such books is of great value from two points of view. It helps to remove the ignorance of average educated Indian of today about the achievements of his ancestors. In the field of two important branches of science, Mathematics and Astronomy, it is really surprising how those ancient astronomers could reach such heights of accuracy with the help of instruments which seem to be laughably crude compared to those that modern astronomers have at their disposal. At the same time a study of such literature is a very salutary corrective

to the vanity of those who feel that in astronomy as in certain other subjects the last word was said by those writers who have written in Sanskrit. We learn how far behind we are in certain very important directions in the field of knowledge.

It is interesting by the way to find that the author of this great work was a Vaishya. This shows how diffused knowledge even of the most abstract subjects was in those days and how Scholarship was honoured irrespective of caste. Not one the critics of Brahma Gupta has taunted him on the ground of his not being a Brahmana.

Sampurnanand
Governor-Rajasthan

Raj Bhavan,
Jaipur,

Dated May 4, 1966.

Observations

of

Dr. K. M. Munshi

President of the Reception Committee

The Author Shri Ram Swaroop Sharma has given to the world of scholars an excellent and valuable treatise on the famous Astronomer Brahma-Gupta, son of Jisṣugupta, born in 589 A. D. in Bhillamala or Srimala now in Southern Marwar close to the northern frontier of modern Gujarat. The work is divided into 13 chapters and at the end of each, the learned author has given reference to other works and treatises for further study as also in support of his various conclusions. He has described Astronomy in Ancient India in the light of the knowledge of the subject available in different countries in his time.

After giving personal details of Brahma-gupta, the author starts on a critical study of the works of that Astronomer—particularly his *Brahma-sphuta-siddhānta* and *Khandana-Khāḍya*. The author has also discussed the Indian Luni-solar Astronomy, the Greek and Hindu methods in spherical Astronomy and the Epicyclic theory of ancient Indians. Discussing in detail the contribution of Brahma Gupta in Arithmetic, Algebra, in Astronomy and the Astronomical instruments that he used, the author has brought out the various highlights of his work and achievements in comparison with those of his predecessors, successors and contemporaries in other countries.

The author deserves to be congratulated for this scholarly contribution on the subject of Ancient Indian mathematics and Astronomy.

—K.M. Munshi

**Bhartiya Vidya Bhawan
Bombay**

Publisher's Note

It is with pride and pleasure that the Indian Institute of Astronomical & Sanskrit Research brings out its second monumental work 'Brāhma Sphuṭa Siddhānta'. The Institute, set up on the 23rd November, 1957, with the object of promoting research into ancient Indian manuscripts on Astronomy and allied Sciences, started its programme of publication with the preparation of a critical edition of Vateshwara Siddhānta running into more than 700 pages. It was far back in early forties that the idea of reviving the treasures of knowledge hidden in ancient manuscripts came to my mind. In 1945 I could succeed in editing and publishing 'Trailokya Prakāśa' of Acharya Hema Prabha Sūri.

Ālbruni's Travel Accounts of India contain a reference to Vateshwara Siddhānta and this fact was responsible for prompting me to arrange publication of Vateshwar Siddhanta. It was rather difficult to search out this manuscript and the clue given by Mahamahopādhyaya Sudhākar Dwivedi (a great Mathematician and Astronomer of 19th century) that the manuscript was available in Gwalior did not lead me to any results. I kept my search on and found a copy of this text in the collection of manuscripts inherited by a Brahman widow of Gujranwala District in west Pakistan. The same style of copy was later seen by me in the Panjab University Library at Lahore.

Vateshwarāchārya, the great writer of Vateshwara Siddhānta, has criticised Brāhma Sphuṭa Siddhānta of Brahma Gupta, in his work. This naturally aroused my curiosity to procure and publish Brahma Sphuṭa Siddhānta so as to provide right perspective to the students of ancient Indian Scientific literature. Moreover, in one of my discussions with the late Dr. K. S. Krishnan, Director, National Physical Laboratories, New Delhi, he referred to Dr. Colebrook (a German Writer) as having translated into English two chapters of 'Brāhma Sphuṭa Siddhānta', namely, Vyakta (Arithmetic) and Ayakta (Algebra). The late Dr. Krishnan showed keen interest in this manuscript and encouraged me in taking up preparation of a critical edition of this text. The Institute is grateful to the Govt. of India (Department of Cultural Affairs) for meeting part of the expenditure on this publication and thereby enabling us to complete our task.

I shall be failing in my duty if I do not mention the great and invaluable contribution made for the success of the Institute by its founder President the late Shri Brijlal Nehru. It was under his able guidance that the Institute started functioning and its various programmes were finalised. His passing away has been a big and irreparable loss to us. The Institute will keep his memories always alive by following his ideals and by executing with zeal the programmes inspired by him.

I must take this opportunity to express my heartfelt gratitudes to Shri B. B. Varma, Member Parliament, who has never shirked in shouldering the responsibilities of managing the affairs of the Institute first as a member of its Executive Council and now as its President. I am also thankful to Dewan Hari Krishan Das, Chairman of the Executive Council and Shri F.C. Bedi Treasurer of the Institute for their ungrudging support to the cause of the Institute.

My thanks are also due to Dr. Sampurnanand, Governor Rajasthan, who has blessed the Institute by inaugurating it and has now been kind to write a foreword for the present book. I am also indebted to Dr. Satya Prakash, Head of the Deptt. of Chemistry, Allahabad University for his having spared time to write an introduction in English for this publication. He has always been cheerfully allowing us to draw on his rich experience and wealth of knowledge. I am also grateful to Pt. Mukund Mishra, Pt. Vishwa Nath Jha, Shri Daya Shankar Dixit and Pt. Om Datt Sharma, the learned scholars who helped me in preparing this work.

The book has been published in four volumes. Volume I includes introduction in English by Dr. Satya Prakash followed by the text as given in the copy of the manuscript obtained from the Bhandarkar Research Institute, Poona, with footnotes to collate the various versions found in the copies of the manuscripts procured from the Royal Asiatic Society, Bombay, the Oriental Research Institute, Baroda and the Vishweshwaranand Vedic Research Institute, Hoshiarpur. The volume also contains a Sanskrit Bhumika from the Chief Editor and an Index of Shlokas. Volume II comprises of the first nine chapters of Brāhma Sphuṭa Siddhānta containing only those readings which we have considered as correct. It also includes Vāsana commentary of Pṛthūdaka Swāmi and Vigyān Bhashya in Sanskrit with Hindi translation. Volume III includes chapters 10 to 16. This volume also contains Nutan Tilak commentary of Sudhakar Dwivedi and Vigyan Bhashya in Sanskrit with Hindi translation. Volume IV comprises of chapters 17 to 24 and also an Index of Shlokas contained in Volumes II, III and IV. It also includes an appendix on Dhayāna Grhaṇādeshadhyāya. Another appendix in this volume contains Vāsana commentary on Golādhyāya.

The Institute has planned to add to its list of publications, shortly, Samrāt Siddhānta (3000 pages and already in press), Brhad Yavan Jātaka (2000 pages) and Panch Siddhāntikā (1600 pages).

The Indian Institute of Astronomical & Sanskrit Research considers it a proud privilege to dedicate Brāhma Sphuṭa Siddhānta to Shri S. K. Patil, Union Minister for Railways. I am highly grateful to him for his having consented to this dedication. I am also grateful to Shri K. M. Munshi and Shri Wadilal Chaturbhuj Gandhi for their kindly agreeing to my request to be President and Chairman respectively of the Reception Committee. My heart felt thanks are also due to Shri Kanti Lal H. Shah, Hony. Secy. of the Organising Committee and to all the members of the organising and the Reception Committees for their help and cooperation in my work. I also owe a debt of grati-

tude to the Patrons of the Institute : His Majesty the King of Nepal, Abhinaya Samrat, Shri Prithvi Raj Kapoor, Shri Dhairyasinh, R. Morarji, Chairman Dharamsi Morarji & Co., Bombay, Shri Pranlal Bhogilal, Patel Bombay for their invaluable help. I am also grateful to the life members of the Institute : H.H. Maharaja Manabendra Shah of Tehri Garhwal, Yuvraj P.C. Dev, Shri B.N. Bhaskar, Shri R.K. Batra, Shri Sada Jivatlal Chandulal, Shri Shiv Kumar Bhuvalka, Shri Janna Das H. Moorjani, Shri Shantilal K. Somaiya, Shri Kisonlal M. Diwanji, Solicitor, Shri N. K. Jalan, Shri D. R. Nayar, Shri Vadilal C. Gandhi, Shri Devi Prasad Khandelval, Shri Ram Prasad Khandelval, Shri B. K. Jalan, Shri Amir Chand T. Gupta, Shri Laxman Vaman Apte, Smt. Padma Koregaonkar, Shri Yodh Raj Bhalla for their support to the Institute.

I must make a special mention here of shri A.N. Jha, Chief Commissioner, Delhi, who has greatly encouraged me in my task of publishing old manuscripts. His help in solving the various problems faced by me, has been invaluable. I am highly grateful to him for his support in my cause. I am also grateful to H. H. Maharaja Manabendra Shah of Tehri Garhwal, Seth Sadajivat Lal Smt. Padma Koregaonkar, Lala Yodh Raj Bhalla, Shri F.A. Fazalbhaj, Shri Morar J. Vaidya, Shri N. J. Aggarwal, Shri P. S. Naulakha, Shri R. L. Maheshwari, Shri D. N. Bhattacharjee, Shri P. A. Narialwala, Shri P. M. Aggrawal, Shri Shiv Kumar Bhuvalka, Shri Navin Bhai Khandwala and Smt. Nirmala Gonde, Lala Jagan Nath Ji, Shri L.S. Aggarwal, Shri B.N. Saxena, Shri R.B. Shah, Shri L.O. Joshi, Shri T.S. Krishnamurti, Shri R. S. Chitkara, Dr. Ram Karan Sharma, Shri V.P. Agnihotri, Shri K.L. Handa and Shri K.G. Somayya for their help and advice at various occasions.

Ram Swarup Sharma

Bombay
17-5-1966.

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भूमिका

ब्रह्मगुप्तकृतो ब्राह्मस्फुटसिद्धान्तः

श्रीचापवंशतिलके श्रीव्याघ्रमुखे नृपे शकनृपाणाम् ।
 पञ्चाशत्संयुक्तैर्वर्षशतैः पञ्चभिरतीतैः ॥
 ब्राह्मः स्फुटसिद्धान्तः सज्जनगरितज्ञगोलवित्प्रीत्यै ।
 त्रिशद्वर्षेण कृतो जिष्णुसुतब्रह्मगुप्तेन ॥

इति ब्राह्मस्फुटसिद्धान्तीयसंज्ञाध्याये आचार्योक्त्या ५२० शाकवर्षे-आचार्यस्य (ब्रह्मगुप्तस्य) जन्म समयस्ततः परं त्रिशति वर्षेषु गतेषु तेन ब्राह्मस्फुटसिद्धान्तसंज्ञको ज्योतिषसिद्धान्तग्रन्थो विरचितः^१ । गुर्जरदेशमध्ये भिनमाल नाम ग्राम एवास्य जन्मस्थानं बहूनां पाश्चात्यानां गवेषणया सिध्यति । गुर्जरदेशीय-ज्योतिर्विदां मुखकथातोऽपि भिल्लमालकोऽधुना भिनमालनाम्ना प्रसिद्धो ग्राम एवाऽऽचार्यस्य जन्मस्थानं सिध्यति । गुर्जरदेशोत्तरसीमायां मालव (माड़वार) देशतो दक्षिणस्यां दिशि आबूपर्वतक्षणीनद्योर्मध्ये तत्पर्वताद्वायुकोरोऽयं भिनमालनामा ग्रामोऽधुना प्रसिद्धोऽस्ति ।

विष्णुधर्मोत्तरपुराणान्तर्गतं ब्रह्मसिद्धान्तमागमीकृत्य ब्राह्मस्फुटसिद्धान्तो ब्रह्मगुप्तेन विरचितः । नलिकादिवेधद्वारेण दृग्गणितैक्यकारि-ग्रहादि साधनकारणात्प्राचीनं ब्रह्मसिद्धान्तं संशोध्य नवीनं ब्राह्मस्फुटसिद्धान्तं रचितवान् ब्रह्मगुप्तः ।

ब्रह्मोक्तं ग्रहगणितं महता कालेन यत् खिलीभूतम् ।
 अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन ॥
 संसाध्य स्पष्टतरं बीजं नलिकादियन्त्रेभ्यः ।
 तत्संस्कृतग्रहेभ्यः कर्तव्यौ निर्णयादेशौ ॥

इत्याद्युक्त्या स्फुटं ज्ञायते । अस्य चतुर्वेदाचार्यपृथूदककृता तिलकसंज्ञिका टीका प्रसिद्धाऽऽसीत् साऽधुना सम्पूर्णा सम्प्रति नोपलभ्यते । 'कोलब्रूक' सारहेवमहोदयैः सम्पूर्णा सा टीको (पृथूदक कृता) पलब्धा तद्वलेनास्य ग्रन्थस्य द्वादशाष्टादशाध्याययोर्व्यक्ताव्यक्तगणितसंज्ञयोराङ्गलभाषायामनुवादः १७६९ शाकवर्षे

१. गुप्तपदान्ताद्वैश्यकुलोत्पन्नो श्रीवानरेशस्य व्याघ्रभट्टेश्वरस्य प्रधानज्योतिषिक आसीदयमिति बहूनां मतमस्ति ।

(१८१७ खीष्टाब्दे) कृत इत्युपलभ्यते । अत्र ब्राह्मस्फुटसिद्धान्तेऽष्टाधिक ग्रहस्य-
 १००८मिता आर्याः सन्ति, तथा पूर्वार्धे १. मध्यगतिः । २. स्पष्टगतिः । ३. विप्रदना-
 ध्यायः । ४. चन्द्रग्रहणाध्यायः । ५. सूर्यग्रहणाध्यायः । ६. उदयास्तमयाध्यायः ।
 ७. चन्द्रशृङ्खोन्नत्यध्यायः । ८. चन्द्रच्छायाध्यायः । ९. ग्रहयुत्यध्यायः, १० भयत-
 युत्यध्यायः, इति दशाध्यायाः सन्ति । परार्धे च १. तत्र परीक्षाध्यायः ।
 २. गणिताध्यायः । ३. मध्यगत्युत्तराध्यायः । ४. स्फुटगन्धुनराध्यायः ।
 ५. विप्रश्नोत्तराध्यायः । ६. ग्रहगोत्तराध्यायः । ७. छेद्यताध्यायः । ८. वासिष्ठ-
 त्युत्तराध्यायः । ९. कुट्टाकाराध्यायः । १०. छन्दश्चित्युनराध्यायः । ११. गो-
 ध्यायः । १२. यन्त्राध्यायः । १३. मानाध्यायः । १४. मंजाध्यायः । इति अष्टाध्या-
 ध्यायाः सन्ति, पूर्वार्धपरार्धाध्याययोर्द्वयेन चतुर्विंशतिराध्याया अत्र ग्रन्थे गन्ति ।
 तेषु तन्त्रपरीक्षाध्यायो विचारार्हः । अत्र बहूनामाचार्याणां नामानि मतानि
 चाचार्यैर्गोलिलिखितानि । यथा—

लाटात् सूर्यशशाङ्को मध्याविन्दूच्च चन्द्रपातो च ।
 कुजबुध शीघ्रवृहस्पति सितशीघ्र शनैश्चरान् मध्यान् ॥
 युगयातवर्षभगरान् वासिष्ठाद्विजयनन्दिकृत्पादात् ।
 मन्दोच्चपरिधि-पात-स्पष्टीकरणाच्चमार्यभटान् ॥
 श्रीषेणेन गृहीत्वा रक्षोच्चयरोमकः कृत्वा कथा ।
 एतानेव गृहीत्वा वासिष्ठो विष्णुचन्द्रेण ॥
 अनयोर्न कदाचिदपि ग्रहणादिषु भवति दृष्टिगणितैक्यम् ।
 यद्भवति तद्घुगाक्षरगतोऽस्फुटाभ्यां किमेताभ्याम् ॥

एभिः श्लोकैः श्रीषेणाचार्यकृतो रोमकविद्धान्तः, विष्णुचन्द्रकृत्वा गो-
 वासिष्ठसिद्धान्तस्तयोर्द्वयं परमाहेति टीकाकृतश्चतुर्वेदाचार्यस्य कथनमस्ति । पञ्च-
 सिद्धान्तिकायां श्रीषेण विष्णुचन्द्रयोरनुत्लेखात् बराहमिहिराचार्यानन्तरं ब्रह्म-
 गुप्ततः पूर्वमेतौ ज्योतिषसिद्धान्तग्रन्थरचयितारावास्ताम् ४२७ शाकवर्षान् पश्चात्
 ५५० शाकवर्षात्पूर्वं तयोः (श्रीषेण विष्णुचन्द्रयोः) रोमकविद्धान्तो वासिष्ठ-
 सिद्धान्तश्चातिगणितस्थौल्यमापन्नाविति स्वयं वेदद्वारा स्थिरीकृत्यैवाऽऽचार्येण
 (ब्रह्मगुप्तेन) प्रौढोक्त्या 'यद्भवति तद्घुगाक्षर'मित्यादि कथ्यते । अत्रार्यभट्टस्य
 सिद्धान्तः सर्वत्रैव दोषावह एवेति वदन्प्याचार्यो (ब्रह्मगुप्तः) बहुधाव तदुक्तीरेव
 खण्डयितुं ग्रन्थमरचयत् । यथा भूभ्रमणं खण्डयति—

प्राणेनैति कलां भूर्यदि तर्हि कुतो ब्रजेत् कमध्वानम् ।

आवर्त्तनमुर्व्याश्चेन्न पतन्ति समुच्छ्रयाः कस्मात् ॥

पृथिव्याश्चलत्वं भगणानां स्थिरत्वं स्वीकृत्य—अहोरात्राभुभिः स्वाक्षो-
परि पृथिव्या भ्रमणं मन्यते आर्यभटेनेति—आवर्त्तनमुप्याश्चेदित्याद्युक्तिः । अन्यत्रा-
नेका अत्युक्तयो दुराग्रहवशात् कुत्रचिद्वाग्बलेन कथिता ब्रह्मगुप्तेन यथा—

स्वयमेव नाम यत्कृतमार्यभटेन स्फुटं स्वगणितस्य ।
सिद्धं तदस्फुटत्वं ग्रहणादीनां विसंवादात् ॥
जानात्येकमपि यतो नार्यभटो गणितकालगोलानाम् ।
न मया प्रोक्तानि ततः पृथक् पृथक् दूषणान्येषाम् ॥
आर्यभटदूषणानां संख्या वक्तुं न शक्यते यस्मात् ।
तस्मादयमुद्देशो बुद्धिमताऽन्यानि योज्यानि ॥

स्वयं ग्रहग्रहणादिवेधकर्त्ता ब्रह्मगुप्तः प्राचीनाचार्येभ्योऽनेकान् विशिष्टान्
ग्रहादिसाधनविधीन् गणितसत्यासत्यपरीक्षार्थं वेधविधींश्च स्वग्रन्थे प्रौढोक्त्या
प्रतिपादयति —

ज्ञातं कृत्वा मध्यं भूयोऽन्यदिने तदन्तरं भुक्तिः ।
त्रैराशिकेन भुक्त्या कल्पग्रहमण्डलानयनम् ॥
यदि भिन्नाः सिद्धान्ता भास्करसंक्रान्तयोऽपि भेदसमाः ।
स स्पष्टः पूर्वस्यां विषुवत्यर्कोदयो यस्य ॥

इत्यादिना वास्तवविचारासक्तः सर्वप्रथमं सर्वतो विशिष्टं विवेचनाबहुलं
सिद्धान्तग्रन्थं ब्रह्मगुप्त एव रचितवानित्युपलब्धज्योतिषसिद्धान्तग्रन्थेभ्यो ज्ञायते ।
'कृती जयति जिष्णुजो गणकचक्रचूडामणि' रितिस्वसिद्धान्तशिरोमणोर्गणिता-
ध्यायारम्भे भास्कराचार्येण ब्रह्मगुप्तमभिवन्द्य तत्परमपि बहुत्रस्थले ब्रह्मगुप्त-
मतोल्लेखं कुर्वताऽपि 'यथाऽत्रग्रन्थे ब्रह्मगुप्तस्वीकृतागमोऽङ्गीकृत' इत्युक्त्या
तद्ग्रन्थानुसारी ग्रन्थो रचित इति प्रतीयते । ब्रह्मगुप्तेनायनचलनं नोपलब्धमिति
ब्रह्मस्फुटसिद्धान्ततो ज्ञायते । अयनचलनोपलब्धिः प्रत्युत खण्डितेति दृश्यते
यथा—

परमल्पाभिथुनान्ते द्युरात्रिनाड्योऽर्कगतिवशादृतवः ।
नायनयुगमयनवशात् स्थिरमयनद्वितयमपि तस्मात् ॥

वराहमिहिरोऽयनचलनसम्बन्धे सन्दिहान् आसीदिति 'नूनं कदाचिदासी-
द्येनोक्तं पूर्वशास्त्रेषु' इति तत्कथनेन ज्ञायते । तत्समयेऽश्विन्यादौ क्रान्तिपात
आसीदित्यश्विन्यादि नक्षत्रगणना प्रवृत्ता सैव ब्रह्मगुप्तात्परमद्यवधि प्रचलति ।

पञ्चषष्ट्या वर्षैः क्रान्तिपातः प्राय एकमंशं पश्चिमदिश्यपसरति तज्ज्ञानं स्वल्प-
कालेनासम्भव इवेति वेधविज्ञेनापि ब्रह्मगुप्तेनायनचलनं नोपलब्धमिति । आर्य-
भटविरोधी भूत्वापि ब्रह्मगुप्तो ब्राह्मस्फुटसिद्धान्तरचनानन्तरं सप्तत्रिंशत्तमे वर्षे
खण्डखाद्यकं नामकरणग्रन्थं रचितवान् यथा तत्प्रारम्भे—

प्रणिपत्य महादेवं जगदुत्पत्तिस्थितिप्रलयहेतुम् ।

वक्ष्यामि खण्डखाद्यकमाचार्यार्यभटनुत्यफलम् ॥

प्रायेणार्यभटेन व्यवहारः प्रतिदिनं यतोऽशक्यः ।

उद्धाहजातकादिषु तत्समफललघुतरोक्तिरतः ॥

इति तदुक्तग्रन्थपर्यालोचनया ज्ञायते यत्सर्वत्र व्यवहारकृतां मानवानां
मध्ये प्रचरितार्यभटमत निराकरणमतीव कठिनमासीदिति—‘आर्यभटमतानुमानि-
व्यवहरतां तात्कालिकजनानामुपकारायैव व्यावहारिकः करणग्रन्थः खण्डखाद्यक-
नामको रचितो ब्रह्मगुप्तेन । यथोपलब्धेषु प्राचीनज्योतिषसिद्धान्तग्रन्थेषु ब्राह्म-
स्फुटसिद्धान्त आदर्शरूपो ग्रन्थस्तथैव सर्वेषां करणग्रन्थानामादर्शरूपमादिमं वा
इतस्त्रयोदशशतवर्षैः प्राचीनं खण्डखाद्यकं करणम् । अथ ‘ब्रह्माह्वयश्रीधरपदम-
नाभबीजानि यस्मादिति विस्तृतानि’ इति बीजगणिते भास्करोक्त्या ज्ञायते
यद्ब्रह्मगुप्तस्य विपुलो बीजगणित ग्रन्थ आसीत्परमयं ग्रन्थः कुत्रापि नोपलभ्यते
न वा श्रूयते । ब्रह्मगुप्त एव सर्वापेक्षया श्रीपतेरादर्शभूतः । ब्राह्मस्फुटसिद्धान्त-
सिद्धान्तशेखरयोः पर्यालोचनया ज्ञायते यद् ब्रह्मगुप्तोक्ताः संक्षिप्ता बहुलार्थयुक्ता
आर्या एव बृहदाकारैश्छन्दोभिरनूदिताः श्रीपतिना । वस्तुतो ब्रह्मगुप्तोक्तं ग्रह-
गणितं सूक्ष्मं ज्ञात्वा सत्यमिव तदेव स्वीकुर्वन् श्रीपतिस्तदुक्तिवैषम्यं स्वसुन्दर-
रचनाभिरपहरन् सुगमतरं ग्रन्थांतरं (सिद्धान्त शेखरं) चकार, नात्र केयामपि
विप्रतिपत्तिः । ग्रन्थरचनासम्बन्धे श्रीपतेर्विशेषतो लल्लाचार्य एवादृशः । ये केचन
विषया ब्रह्मगुप्तेन न कथिता अथ लल्लेन कथितास्तान् सर्वानेव नियतमेव
श्रीपतिः श्लोकान्तरेण तथैव कथितवान् । वस्तुतो द्वयोर्ग्रन्थयोः (ब्राह्मस्फुट
सिद्धान्तशिष्यधीवृद्धिद्वयोः) परिशीलनं कृत्वा श्रीपतिना सिद्धान्तशेखरो रचितः ।
ब्राह्मस्फुट सिद्धान्ते येषामाचार्याणां नामानि समागतानि सन्ति तेषां सम्बन्धे
किञ्चिद्विचिन्त्यते । सर्वेषां सिद्धान्तानामादिमः सर्वेभ्यः प्राचीनो वा ब्रह्मसिद्धान्त
एव, स एव कैश्चित् पितामहसिद्धान्तनाम्नाप्युच्यते । पञ्चसिद्धान्तिकायां
वराहमिहिरेण द्वादशोऽध्याय आर्यापञ्चात्मकः पितामहसिद्धान्तः कथितो
यथा—

रविसंज्ञिनोऽञ्चयुगं वर्षाणि पितामहोपदिष्टानि ।

अधिमासस्त्रिंशद्भिर्मासैरवमस्त्रिषष्ट्याऽह्नाम् ॥

द्व्यधूनं शकेन्द्रकालं पञ्चभिर्दधृत्य शेषवर्षाणाम् ।
 द्विगुणं माघसिताद्यं कुर्याद् द्युगुणं तदन्हुदयात् ॥२॥
 सैक षष्ठ्यंशे गणे तिथिर्भमार्कं नवाहतेऽक्षयर्कः ।
 दिग्रसभागैः सप्तभिर्नूनं शशिभं धनिष्ठाद्यम् ॥३॥
 प्रागर्ध्वं पर्वं यदा तदोत्तराऽतोऽन्यथा तिथिः पूर्वा ।
 अर्कघ्ने व्यतिपाता द्युगणे पञ्चाम्बरहुताशैः ॥४॥
 द्व्यग्निनगेषूत्तरतः स्वमितमेष्य दिनमपि याम्यायनस्य ।
 द्विघ्नं शशिरसभवतं द्वादशहीनं दिवसमानम् ॥५॥

एतदनुसारेणैकस्मिन् युगे सौरवर्षाणि = ५, सौरमासाः = $५ \times १२ = ६०$ ।
 अधिमासौ = २ । चान्द्रमासाः = ६२ एते त्रिशद्व्युगितास्तिथयः = १८६०, अव-
 मानि = ३०, एभी रहितास्तिथयोऽहर्गणः = १८३० इति ॥

पञ्च सिद्धान्तिकायां 'पौलिश सिद्धान्तः' इति नाम्ना एकोऽध्यायो वर्तते,
 ब्राह्मस्फुट सिद्धान्तटीकायां पृथूदकेन बहून्येव पौलिशसिद्धान्तवचनानि प्रमाण-
 त्वेनोद्धृतानि सन्ति । अस्य सिद्धान्तरचयितुः सम्बन्धे बहूनि मतान्तराणि सन्ति ।
 वराहोक्तपौलिशसिद्धान्ते यवनपुरात् उज्जयिन्या वाराणस्याश्च देशान्तर-
 मुल्लिखितमस्ति । यथा —

भवनाच्चरजा नाड्यः सप्तावन्त्यां त्रिभागसंमिश्राः ।
 वाराणस्यां त्रिकृतिः साधनमन्यत्र वक्ष्यामि ॥

शाकल्यसंहितोक्त ब्रह्मसिद्धान्ते पुलिशसिद्धान्तोल्लेखो वर्तते । ब्राह्मस्फुट-
 सिद्धान्तटीकायां पृथूदकेन 'देशान्तर रेखा च पौलिशे पठ्यते' इत्युक्तम् । तथा च
 पुलिशाचार्यः—

उज्जयिनी रोहीतककुसुमुनाहिमनिवासमेरूणाम् ।
 देशान्तरं न कार्यं तल्लेखामध्यसंस्थदेशेषु ॥'

इत्यादि विचारेण पौलिशसिद्धान्तः सर्वमान्य आसीदिति प्रतिभाति ।
 परमयं सिद्धान्तः साम्प्रतं नोपलभ्यते इति ।

सूर्य सिद्धान्त एव प्राचीनतमः सर्वप्रथमः सिद्धान्तग्रन्थ इति बहूनां विदुषां
 मतम् ।

'केचित्प्रत्यक्षसूर्याच्च भिन्नोऽयमिति यद्वलात् ।
 वदन्ति मूढवाद्स्याप्रामाण्यात्तदसद्भवम् ॥'

इति कमलाकरोत्तया स्वयं भगवान् सूर्य एवास्य रचयिता । आश्चर्यम्य विषयोऽयमस्ति यदत्रा (सूर्यसिद्धान्ते) यनांशानयनम् ।

‘त्रिशत्कृत्यो युगे भानां चक्रं प्राक् परिलम्बते ।
तद्गुणाद्भूदिनैर्भक्ताद् द्युगुणाद्यदवाप्यते ॥’
‘तद्दोस्त्रिधना दशाष्टांशा विज्ञेया अयनाभिधाः ।
तत्संस्कृताद् ग्रहात् क्रान्तिच्छाया चरदलादिकम् ॥’

इत्यनेन कृतमस्ति । परं ब्राह्मस्फुटसिद्धान्तनिर्मात्रा ब्रह्मगुप्तेन तस्य (अयनांशस्य) चर्चाऽपि न कृता । कथं ब्रह्मगुप्तेन तच्चर्चा न कृतेति न ज्ञायते । सूर्य सिद्धान्तस्योदयास्ताधिकारे ‘अभिजिद् ब्रह्महृदयं स्वातीवैष्णव वासवाः’ इत्यादिना सदोदित नक्षत्राणि भगवता सूर्येण कथितानि सन्ति, अस्य श्लोकस्य सुधावर्षिणी टीकायां ‘देशज्ञानं विना सदोदित नक्षत्राणां ज्ञानं न भवति निरक्षे च सौम्यध्रुवोऽप्यदृश्योऽतः केनचिद्गोलानभिज्ञेनायं श्लोकः प्रक्षिप्तः, इति यल्लिखितमस्ति तत्समीचीनं नास्ति । पाताधिकारे पातस्थितिकालस्य फलं—

आद्यन्तकालयोर्मध्यः कालो ज्ञेयोऽतिदारुणः ।
प्रज्वलज्ज्वलनाकारः सर्वकर्मसु गर्हितः ॥
एकायनगतं यावदकेन्द्रोर्मण्डलान्तरम् ।
सम्भवस्तावदेवास्य सर्वकर्मविनाशकृत् ॥
स्नानदानजपश्राद्धव्रतहोमादिकर्मभिः ।
प्राप्यते सुमहच्छ्रेयस्तत्कालज्ञानतस्तथा ॥

इत्यनेन पातस्थितिकालः सर्वकर्मविनाशकृदुक्तः । पातकाले स्नानदान-जपश्राद्धव्रतहोमादिकर्मभिर्महत्कल्याणं प्राप्यते लोकैरिति । तथा च—

रवीन्द्रोस्तुल्यता क्रान्त्योर्विषुवत्सन्निधौ यदा ।
द्विर्भवेद्वि तदा पातः स्यादभावो विपर्ययात् ॥

इत्यनेनापूर्वविषयः कथितोऽर्थाद्विगोलसन्धिसमीपे यदा रविचन्द्रयोः क्रान्तिसाम्यं भवेत्तदाऽल्पेनैव कालेन द्विवारः पातः स्यात् । यदा रव्ययनसन्धि-समीपे क्रान्तिसाम्याभावस्तदा बहुकालपर्यन्तं क्रान्ति साम्याभावः स्यादिति ।

ब्राह्मस्फुटसिद्धान्तेऽपि पातस्थितिकालफलं सूर्यसिद्धान्तोक्तवत्कथितम् । सिद्धान्तशेखरे कियत्कालपर्यन्तं पातफलमिति ‘भानोर्बिम्बं तुहिनकिरणापक्रमे-णौकमार्गं यावत्तावन्मुनिभिरुदितसंभवस्तत्फलस्य । तस्याभावे भवति नियतं

तत्फलस्याप्यभावो यात्रोद्वाहादिषु पुनरिह द्युत्रयं नैव दुष्टम् ॥' अनेन कथितम्, अर्थात्सूर्यविम्बं तुहिनकिरणापक्रमेण (चन्द्रस्य स्पष्टक्रान्त्या सह) यावत्काल-पर्यन्तमेकमार्गं (एकस्मिन्नहोरात्रवृत्तेऽर्थाद्यावत् क्रान्त्योर्विवरं मानैक्याधादित्यं भवति यथा बिम्बैकदेशजक्रान्त्योः साम्यं भवतीत्यर्थः ।) तावत् मुनिभिः फलादेश-कृद्भिः पातसंज्ञातफलस्य संभवः कथितः । तस्य सूर्यस्य चन्द्रस्य स्पष्टक्रान्त्या सहैकमार्गावस्थानाभावे तत्फलस्याप्यभावो भवति । इह पुनः पातस्थितिकाले यात्रोद्वाहादिषु मङ्गलकार्येषु दिनत्रयं दुष्टं नैव । केचुचित्फलग्रन्थेषु व्यतीपात-वैधृतयोः सतीस्तद्दिनं तत्पूर्वदिनमपरदिनं चेति दिनत्रयं शुभकार्ये निषिद्धमिति कैश्चिदुक्तं तत्परिहारार्थमाह—द्युत्रयं नैव दुष्टम् । सूर्यसिद्धान्तादिषु पातकाल एव शुभकार्येषु दोषभाक् गते पातकाले च दोषो न भवतीति । प्रसङ्गादत्र सिद्धान्तशेखरवचनोल्लेखः कृतः । यतः श्रीपतिराचार्या(ब्रह्मगुप्तात्) दर्वाचीनोऽस्ति । ब्राह्मस्फुट सिद्धान्ते तन्नामोल्लेखो नास्ति ।

भारतीयानां ज्योतिर्विदां मध्ये आर्यभट्ट एव सर्वप्रथमं दिनरात्रयोः कारण-स्वरूपं पृथिव्या आवर्तनं कथयति । यथा गीतिकापादस्य प्रथमश्लोके एकस्मिन् महायुगे ४३२०००० भूमेर्भगणाः १५८२२३७५०० एतावन्तो भवन्तीति प्रथमं कथयित्वा दृष्टान्तद्वारेण भूभ्रमणं—

अनुलोमगतिर्नोऽस्थः पश्यत्यचलं विलोमगं यद्वत् ।

अचलानि भानि तद्वत् समपश्चिमगानि लङ्कायाम् ॥

अनेन दृढीकरोति । परमत्र विचित्रमेतदवलोक्यते यदार्यभट्टीय टीका-कारेण परमेश्वरेणैतत्-श्लोकस्यावतरणं 'भूमेः प्राग्गमनं नक्षत्राणां गत्यभावञ्चे-च्छन्ति केचित्तन्मिथ्याज्ञानवशादुत्पन्नां प्रत्यग्गमनं प्रतीतिमङ्गीकृत्य भूमेः प्राग्ग-तिरभिधीयते । परमार्थतस्तु स्थिरैवभूमिः' इत्युक्तम् । स्वयमप्यार्यभट्टः—

उदयास्तमय निमित्तं नित्यं प्रवहेण वायुना क्षिप्तः ।

लङ्कासमपश्चिमगो भपञ्जरः सग्रहो भ्रमति ॥

इत्यनेन भूभ्रमणमस्वीकरोतीति दृश्यन्ते । आर्यभट्टस्य मनसि निश्चयो नासीद्यत् पृथिवी चलति-नवा चलति । ब्रह्मगुप्तेनैकमपूर्वं वस्तु 'नतकर्म' प्रति-पादितम् । मन्दफल-शीघ्रफल-भुजान्तरादि संस्कारेण यो हि स्पष्टग्रहः समा-गच्छति स स्वगोलीयः (ग्रहगोलीयः) स ग्रहोऽस्माकं यत्र प्रत्यक्षोभूतो भवति स एवास्माकं स्पष्टग्रहो भवितुमर्हति । स्वगोलीयस्पष्टग्रहे यावता संस्कारेणास्माकं स्पष्टग्रहो भवति तस्यैव संस्कारस्य नाम 'नतकर्म' ब्रह्मगुप्ततः कोऽपि प्राचीना आचार्या एतस्य (नतकर्मणः) नामोल्लेखं न कृतवन्तः । भास्कराचार्येण सिद्धान्त-

शिरोमणोर्गणिताध्यायस्य स्पष्टाधिकारे-एतस्याऽनयन प्रकारोऽभिहितः । 'मुहुः स्फुटातो ग्रहणे रवीन्द्रोस्तिथिस्त्विदं जिष्णुसुतो जगाद' इति भास्करोक्तेर्जायते यदेतस्याविष्कर्त्ता ब्रह्मगुप्त एवास्ति । भास्कराचार्येण भोग्यखण्डस्पष्टीकरणं यदभिहितं तन्मूलमपि ब्राह्मस्फुटसिद्धान्तस्य ध्यानग्रहोपदेशाध्याये ब्रह्मगुप्तोक्तमेव, न ह्यन्यैराचार्यैस्तत्सम्बन्धे किमपि लिखितम् । कमलाकरेण तु सिद्धान्त-तत्त्वविवेके भास्करोक्तभोग्यखण्डस्पष्टीकरणस्य खण्डनमेव कृतम् । वस्तुनः कमलाकरोक्तं खण्डनं न समीचीनम् । ब्राह्मस्फुटसिद्धान्ते त्रिप्रदनाधिकारे दिक्साधने 'पूर्वापरयोर्विन्दू तुल्यच्छायाग्रयोर्दिगपराद्यः । पूर्वान्यः क्रान्तिवशात् तन्मध्याच्छङ्कुतल मितरे' इत्यत्र क्रान्तिवशाद्विक्साधने कथं भेद उत्पद्यते तदर्थं चतुर्वेदाचार्येण कर्णावृत्ताग्रान्तरं यत्साधितं तदेव 'छायानिर्गमनप्रवेशसमयार्क-क्रान्तिजीवान्तरमि' त्याद्युक्त्या श्रीपतिना, तदनु 'तत्कालापम जीवयोस्तुविबरादि' त्यादिना भास्करेण च गृहीतम् । मन्दफलानयने वस्तुतो मन्दकर्णानुपातेनैव मन्दफलं सिध्यति । यद्यप्यत्र भास्करेण स्वमतं न प्रतिपादितं तथापि चन्द्रग्रहणो स्फुटरविचन्द्रकर्णासाधने 'मन्दश्रुतिर्द्राक्श्रुतिवत् प्रसाध्या' इत्यादिना ब्रह्मगुप्त-स्यैव मतं स्वीकृतमित्यपि ब्रह्मगुप्तोक्तेर्वैलक्षण्यमस्ति । लल्लाचार्येण बलनदृक्-मणोरानयनमुत्क्रमज्ययाकृतमिति ब्रह्मगुप्तोक्तौ 'अत्र ज्याशब्देनोत्क्रमज्या ग्राह्येति' चतुर्वेदाचार्यव्याख्यानमेव लक्ष्यीकृत्य भास्करेण 'ब्रह्मगुप्तकृतिरत्र-सुन्दरी साऽन्यथा तदनुगैर्विचार्यते' इत्युक्तम् ।

‘युगमन्वन्तरकल्पाः कालपरिच्छेदकाः स्मृतावुक्ताः ।

यस्मान्न रोमके ते स्मृतिवाह्यो रोमकस्तस्मात् ॥’

(ब्राह्मस्फुट सिद्धान्त अध्याय १)

इति ब्रह्मगुप्तोक्त्या 'रोमक' इति नाम्ना चायं कस्यचित्पाश्चात्यज्यो-तिर्विदो मूलमादाय रोमकसिद्धान्तो रचित इति स्फुटं भवति । प्राचीनाचार्याणां मध्ये केवलं ब्रह्मगुप्त एव रोमकमतं खण्डयति । वराहमिहिरस्तु रोमक सिद्धान्तमतेनाहर्णरादीनां बहूनामेव सिद्धान्तोक्तविषयाणां साधनं स्वीकरोति । ब्रह्मगुप्तः—

ब्रह्मोक्तं ग्रहगणितं महता कालेन यत् खिलीभूतम् ।

अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन ॥

इत्युक्त्या ब्रह्मसिद्धान्तमेव संस्कृतवानिति स्फुटमेव । तदेतेषां मूलरूप एको ब्रह्मसिद्धान्तोऽतिप्राचीन आसीदिति सिद्ध्यति । ब्रह्मगुप्तस्तु—

येऽज्ञानपटलरुद्धदृशोऽन्यं ब्राह्माद्वदन्ति सिद्धान्तम् ।

तेषां युगादिभेदे ये दोषास्तान् प्रवक्ष्यामि ॥’

इत्युक्त्याऽन्यान् सर्वान् सिद्धान्तान्निन्दन्ति । ब्राह्मस्फुटसिद्धान्ते बहुषु स्थलेषु स्थौल्यं त्वस्त्येव तथापि बहवो विषया अत्र निवेशिताः सन्ति, तस्मात्सर्वश्रेष्ठो ब्राह्मस्फुटसिद्धान्तोऽस्तीतिकथने न काचिद्विप्रतिपत्तिः प्रतिभाति । अत्रैकोऽध्यायो 'छन्दश्चित्युत्तराध्यायः' अस्ति, यत्र लिखितानां श्लोकानां व्याख्योपपत्तिश्चाद्यावधि केनापि न कृता तेषु तादृशं काठिन्यमस्ति यदर्थो न मनसि समागच्छति, उपपत्तेश्च कथं व का ?, प्रश्नाध्यायो यादृशोऽत्र ग्रन्थेऽस्ति न तादृशोऽन्येषु सिद्धान्तग्रन्थेषु । अत्र ग्रन्थे मध्यगत्यादीनां पञ्चाध्यायानां प्रश्नाः सौत्तराः पृथक् पृथक् लिखिताः सन्ति । येषामभ्यासेन पाठका अतीव सिद्धान्तग्रन्थे निपुणा भवितुमर्हन्ति । सिद्धान्तशिरोमणेर्भूमिकायां 'जीवासाधनं विनैव यद्भुजज्यानयनं कृतवान् श्रीपतिस्तत्त्वपूर्वमेव स्यात् । यथा तत्प्रकारो विदां विनोदाय प्रदर्श्यते —

दोः कोटिभागरहिताभिहताः खनागचन्द्रास्तदीयचरणेन शराकदिग्भिः ।
ते व्यासखण्डगुणिता विहृताः फलं तु ज्याभिर्विनापि भवतो भुजकोटिजीवे ॥

इति केनापि लिखितमस्ति तन्नैव युक्तियुक्तं यतो ज्याभिर्विना भुजकोटिज्ययोरानयनं ज्यातश्चापानयनं च सर्वप्रथमं ब्रह्मगुप्तेनैव कृतम् यथा तदुक्तप्रकारः —

भुजकोट्यंशोनगुणा भार्धाशास्तच्चतुर्थभागोनैः ।
पञ्चद्वीन्दुखचन्द्रविभाजिता व्यासखलगुणिता ॥
तज्ज्ये परमफलज्या सङ्गुणिता तत्फले विना ज्याभिः ।
इष्टोच्चनीचवृत्तव्यासार्धं परमफलजीवा ॥^१

इष्टज्यातश्चापानयनञ्च

इष्टज्यासङ्गुणिताः पञ्चकयमलैकशून्यचन्द्रमसः ।
इष्टज्यापादयुतव्यासार्धं विभाजिता लब्धम् ॥
नवतिकृतेः प्रोह्यपदं नवतेः संशोध्य शेषभागकलाः ।
एवं धनुरिष्टाया भवति ज्याया विना ज्याभिः ॥

१. चिरादेव प्रकारोऽयं श्रीपत्युक्तोऽस्तीति ज्योतिर्विदां मध्ये प्रसिद्धोऽस्ति । तथैव ज्यातश्चापानयनमपि । एतदवलम्ब्यैव ग्रहलाघवे करणग्रन्थे गणेशदेवसेन बहवः प्रकारा विलिखिताः ।

एतदनुरूप एव बटेश्वरसिद्धान्ते बटेश्वरेण स्वीयप्रकारोऽभिहितः । सिद्धान्तशेखरे सर्वत्र श्रीपतेः स्वकीयः प्रकारोऽप्युपयानेवास्ति, ब्रह्मगुप्तोक्त-प्रकारा एव छन्दोऽन्तरेण लिखिताः सन्ति' वराहोक्त पञ्चसिद्धान्तिकायां त्रयो-दशभिरार्याभिरुक्तो वासिष्ठसिद्धान्तः पैतामहसिद्धान्तश्च वराहोक्त्यैव दूरभ्रष्टा-विति तत्रापि ब्रह्मसिद्धान्तापेक्षया यत्किञ्चित् वासिष्ठसिद्धान्तः सूक्ष्मताभिधायि । तन्त्रपरीक्षाध्याये—

लाटात् सूर्यशशाङ्कौ मध्याविन्दूच्च चन्द्रपातो च ।
कुजबुधशीघ्रबृहस्पति सितशीघ्रशनैश्चरान् मध्यान् ॥
युगजातवर्ष भगणान् वासिष्ठाद्विजयनन्दिकृत पादात् ।
मन्दोच्चपरिधिपातस्पष्टीकरणाद्यमार्यभटात् ॥
श्रीपेरोन गृहीत्वा रत्नोच्चयरोमकः कृतः पन्थाः ।
एतानेव गृहीत्वा वसिष्ठो विष्णुचन्द्रेण ॥

इति ब्रह्मगुप्तोक्त्या वसिष्ठसिद्धान्तरचयिता विष्णुचन्द्रनामकः कश्चि-दासीत् । सम्भवतोऽयं विष्णुचन्द्रः प्राचीनं वसिष्ठसिद्धान्तं संस्कृतवानिति 'एतानेव गृहीत्वा वासिष्ठो विष्णुचन्द्रेण' इत्युक्त्या स्फुटं भवति । परमयं ग्रन्थोऽधुना कुत्रापि नोपलभ्यते । एतस्यैव विष्णुचन्द्रस्य मतं यत्र तत्र श्रीपेगायं-भटाभ्यां सह ब्रह्मगुप्तेन खण्डितम् ।

१. यथोदाहरणार्थं' किञ्चित्प्रोच्यते । सिद्धान्तशेखरस्य सूर्यग्रहणाधिकारे ।

तिथ्यन्तात् स्थितिलखण्हीन सहितात् प्राग्वत्ततो लम्बनं
कुर्यात् प्रग्रहमोक्षयोः स्थितिदलं युक्तं विधायामकृत् ।
तन्मध्यग्रहणोत्पलम्बनभुवा विदलेषणानेहसा
मर्दाधोनयुताथितेरपि तथा संमीलनोन्मीलने ॥
अधिकमृणयोराद्यं मध्यात्तथाऽन्यमिहाल्पकं भवति
धनयोश्चाद्यं हीनं यदाऽधिकमन्तिमम् ।
नमनविवरेणैवं कुर्याद्विहीनमतोऽन्यथा स्थितिदल-
मृणस्वस्थे भेदे तदैक्ययुतं पुनः ॥

इति ब्रह्मगुप्तोक्ततस्या—

प्राग्वत्लम्बनमसकृत् तिथ्यन्तात् स्थितिदलेन हीनयुतात् ।
अधिकोत्तं तन्मध्यादृणयोक्त्याधिकं धनयोः ॥
यद्यधिकं स्थित्यर्थं तदाऽन्तरेणान्यथोनमृणमेकम् ।
अन्यद्वनं तदैक्येनाधिकमेवं विमर्दाधे ॥

(शेष पृष्ठ ११ पर)

न च श्रीपतिरेव निजपूर्ववर्तिनां ग्रन्थकाराणां ग्रन्थेभ्यस्तदुक्तविषयान् छन्दोऽन्तरेण तथैव निबध्य स्वग्रन्थे स्वोक्त्या लिखितवानपितु तत्पूर्ववर्तिनां ग्रन्थकाराणामपि सैव रीतिः । परवर्तिनो भास्कराचार्यादयोऽपि न तां रीतिममुञ्चन्ति प्रत्यक्षदर्शनादेव स्फुटीभवति ।

यथा भास्कराचार्यः—गणिताध्यायस्य मध्यमाधिकारे सिद्धान्तग्रन्थलक्षणं ज्योतिः शास्त्रस्य वेदाङ्गत्वं निरूपणं वेदाङ्गानां नामानि वेदाङ्गेषु ज्योतिः शास्त्रस्य प्राधान्यं तच्च द्विजैरेव पठनीयमिति सर्वं परतोऽपि भचक्रचलनं काल-

ऽस्य सर्वथा सदृशमेव तथा च प्रकारान्तरेण स्फुट स्थितिं दल साधनं श्रीपत्युक्तम् ।

स्थित्यर्थोनयुतात् परिस्फुटतिथेः स्थाल्लम्बनं पूर्ववत्
तन्मध्यग्रहवेच मध्यमतिथौ ततस्तु तिथौ ।

स्थित्यर्थेन परिस्फुटेषु जनितेनोनाधिकाद्वाऽसकृत्
तत्तिथ्यन्तर नाडिकाः स्थितिदले स्तः स्पर्शमुक्त्योः स्फुटे ॥

अस्य श्लोकस्य द्वितीयं चरणं शुद्धं नास्ति । प्रकारोऽयं ब्रह्मगुप्तोक्तस्या—

स्फुटतिथ्यन्ताल्लम्बनमसकृत् स्थित्यर्थहीनयुक्ताद्वा ।
तत्स्फुट विक्षेपकृत स्थित्यर्थोनयुततिथ्यन्तात् ॥

तत्स्पष्टतिथिच्छेदान्तरे स्फुटे दिनदले विहीनयुतात् ।
स्व विमर्दाधेनासकृदेवं स्पष्टे विमर्दाधे ॥

ऽस्य पुनरुक्तिरेव । सिद्धान्तशिरोमणौ—

तिथ्यन्ताद्गणितागतात् स्थितिदलेनोनाधिकाल्लम्बनं
तत्कालोत्पन्नतीषु संस्कृति भव स्थित्यर्थहीनाधिके ।

दर्शान्ते गणितागते धनमूलां वा तद्विधायसकृज्
ज्ञेयौ प्रग्रहमोक्ष संज्ञसमयावेवं क्रमात् प्रस्फुटौ ॥

भास्करोक्तमपि सर्वथैव तदनु रूपमेवास्ति । एवं सिद्धान्तशेखरस्य सूर्यग्रहणाध्यायोप-
संहारे स्फुटं भवति पञ्चजीवया लम्बनं नहि यतस्ततः कृतम् । युक्तमुक्तमिति जिष्णुसूनुना
तन्मयाऽपि कथितं परिस्फुटम् इति ब्रह्मगुप्तोक्तस्या—

हृग्गणितैक्यं न भवति यस्मात् पञ्चज्यया रविग्रहणे ।
तस्माद्यथा तदैक्यं तथा प्रवक्ष्यामि तिथ्यन्ते ॥

ऽस्य सदृशमेव । मध्यगत्यध्यायतो ग्रन्थ समाप्तिं यावत्सादृश्यस्यैवमेव स्थितिरिति
द्वयोर्ग्रन्थयो 'ब्रह्मस्फुट सिद्धान्त सिद्धान्तशेखरयोः' रचलोकनेन स्फुटं भवतीति* ।

प्रवृत्तिः । कालमानानां परिभाषाः सर्वाः, ग्रहाणां भगणाः, युगानां मन्वादीनां नामानि मानानि च ब्रह्मणो गतवर्षादिः प्रयोजनाभाव इत्यादि सर्वमपि मध्य-
माधिकारोक्तं श्रीपतेः साधनाध्यायोक्तश्लोकानां श्लोकान्तरमात्रमेवाकरोन् ।
सुधियो ग्रन्थाभ्यन्तरे ग्रन्थकारयोराणुरूप्यमवलोकयन्तु । एवं प्राचीनकृतेरनेकान्
विशेषान् प्रवक्तुमेव श्रीपतिः प्रथमं (साधनाध्यायं) ग्रहभगणाध्यायं वा कृतवान् ।
तत्परं मध्यमाध्यायेऽप्यभिः प्रकारैरहर्गणानयनं, कदा प्रभृति वारप्रवृत्ति-
रित्यत्र बहूनामाचार्याणां मतानि, तद्दृष्टव्यपुरःसरस्वाभिमतवारप्रवृत्तिनयनं,
मध्यमग्रहसाधनार्थं बहून्वेव नूतनानि प्रकारान्तराणि, ख्यादीनां सर्वपामपि
ग्रहाणां राश्यादिमन्दोच्चकथनमित्यादयो बहवोऽपि श्रीपतिकृताप्राचीनकृते-
विशेषा वर्तन्ते ।

ब्राह्मस्फुट सिद्धान्ते बहुभिरेव प्रकारैरहर्गणानयनं लघ्वहर्गणानयनं ब्रह्म-
गुप्तेन कृतं, आचार्योक्ताहर्गणानयनस्यानुकरणमेव श्रीपतिना कृतम् । परं सिद्धान्त-
शेखरे लघ्वहर्गणानयनस्य चर्चा ग्रन्थकृता न कृता । अहर्गणाद्वारज्ञानार्थमहर्गणाः
सैकः कार्य इति ब्रह्मगुप्तेन श्रीपतिना च कथितः । परमहर्गणो निरेकोऽपि कत्तव्यो
वारज्ञानार्थमिति सिद्धान्तशिरोमणौ 'अभीष्टवारार्थमहर्गणश्चेत्सैको निरेकस्तिथ-
योऽपि तद्वदित्यनेन भास्कराचार्यः कथयति । वटेश्वरसिद्धान्तेऽपि बहुभिः
प्रकारैरहर्गणानयनं लघ्वहर्गणानयनं च तद्ग्रन्थकृता कृतमस्ति । भास्करा-
चार्यस्तु महदहर्गणानयनं 'कथितकल्पगतोऽर्कसमागण' इत्यादिना, लघ्व-
हर्गणानयनं च 'चैत्र सितादिगतस्थिति संघ' इत्यादिना कृतम् । यद्यपि लघ्व-
हर्गणानयने स्थौल्यं वर्तते तथाप्येकमपूर्वं वस्तु प्रतिपादितम् । वटेश्वरकृतं लघ्व-
हर्गणानयनं स्थौल्यरहितं नास्ति, एतदतिरिक्तैः प्राचीनाचार्यैर्नवीनैश्च लघ्व-
हर्गणानयनं न कृतं प्रत्युत कमलाकरेण भास्करकृतलघ्वहर्गणानयनस्य
खण्डनमेव कृतम् । स्फुटगत्यध्याये सर्वैरेवार्यभट्टब्रह्मगुप्त लल्लाचार्यादिभिर्वृत्त-
चतुर्थांशे चतुर्विंशतिः क्रमज्या उत्क्रमज्याश्च तत्त्वादि २२५ कलावृद्ध्या साधिता-
स्तत्र आर्यभट्टस्य लल्लस्य च त्रिज्या = ३४३८, ब्रह्मगुप्तस्य खमुनिरद ३२७० मिता
त्रिज्या, श्रीपतिना चैतद्भिन्ना ३४१५ त्रिज्या गृह्यता ब्रह्मगुप्तोक्तभूपरिधिः =
५०००, भास्कराचार्यमतेन पादोनगोक्षधृतिभूमितयोजनातीत्यनेन ग्रहाणां
योजनगतिः = ११८५८४५। गतियोजनतिथ्यंशः कुदलस्य यतोमतिरित्यनेन
भूव्यासः = १५८१, भूपरिधिः = ४९६७ ग्रहाणां भुजान्तरकर्म प्रतिपादितमस्ति,
सूर्यसिद्धान्तोक्त भुजान्तरकर्मवदेवास्ति, सिद्धान्तशेखरे, सिद्धान्तशिरोमणावपि
भुजान्तरकर्मण उपपादनमाचार्योक्तवदेवास्ति, अन्येऽपि बहवो विषयादर्शनीयाः
पठनयोग्याश्चेति ।

त्रिप्रश्नाधिकारे रवेर्मध्याह्नकालिकनतांशान् ज्ञात्वा तद्वशतो ख्यानय-
नार्थं प्रथमतः क्रान्तिज्यासमागच्छति । ततोऽनुपातेन रवेर्भुजांशज्ञानं भवति ।

भुजांशतो राश्यादिरवेर्ज्ञानं पदाधोनं तत्र पदज्ञानोपायः प्राचीनैः कैश्चिन्न कृतः,
यथाऽत्राचार्येण—

‘क्रान्तिव्यसार्धगुणा जिनभागज्याहृता धनुरजादौ ।

कव्यादौ चक्रार्धत्प्रोह्य तुलादौ सचक्रार्धम् ॥

चक्रार्धत्प्रोह्यमृगादौ स्फुटो सकृत् व्यस्तमृगं धनं मध्यम् । अर्कोऽस्मादिति
एतेन रवेरानयनं कृतम् । श्रीपतिना ‘अजतुलादिगतस्य विवस्वतो दिनदलप्रभयो-
युतिरर्धिता । भवति वैवृवती निजदेशजे’ त्यनेन पलभामानं ज्ञात्वा—

‘आद्येपदेऽपचयिनी पलभाऽल्पिका स्यात् छायाल्पिका भवति वृद्धिमती द्वितीये ।
छायाधिका भवति वृद्धिमती तृतीये तुर्येषुनः क्षयवती तदनल्पिका च ॥
वृद्धिं प्रयान्ती यदि दक्षिणाग्रच्छाया तथापि प्रथमं पदं स्यात् ।
ह्रासं व्रजन्तीमथ तां विलोक्य रवेर्विजानीहि पदं द्वितीयम् ॥’

इत्यनेन गोलयुक्तिसिद्धं पदज्ञानं कृतम् । अत्र भास्कराचार्यः—

क्रान्तिज्या त्रिज्याघनी जिनभागज्योद्धृता दोज्या ।

तद्धनुराद्ये चरणे वर्षस्यार्कः प्रजायतेऽन्येषु ॥

भार्धाच्च्युतः सभार्धो भगणात्पतितोऽब्द चरणानाम् ।

ऋतुचिन्हैर्ज्ञानं स्यादृतुचिन्हान्यग्रतस्ततो वक्ष्ये ॥’

इत्यनेनाचार्योक्तवदेव कथितवान् केवलं ‘ऋतुचिन्हैर्ज्ञानं स्यादिति’ विशेषं
कथितवान् । पदज्ञानार्थमृतुवर्णननामकमेकमधिकारं सिद्धान्तशिरोमणौगोला-
ध्यायेऽभिहितम् । भास्करतो नवीनाः कमलाकरतः प्राचीनाः सर्वेऽपि सिद्धान्त-
ग्रन्थकर्तारो ज्योतिषसिद्धान्तस्यैकमङ्गं ज्ञात्वा स्वस्वसिद्धान्तग्रन्थे निश्चितरूपेण
‘ऋतुवर्णनाध्यायः,’ प्रोक्तवन्तः । सिद्धान्ततत्त्वविवेकै आद्ये पदेऽपचयिनी
पलभाऽल्पिका स्या’ दित्यादि श्रीपत्युक्त पदज्ञानबोधक श्लोकद्वयं लिखित्वा
कमलाकरेण—

‘ऋतुचिह्नैरिदं पूर्वैरुक्तं सर्वत्र तन्न हि ।

केवलं कुकविप्रीत्यै पदज्ञप्त्यै न तद्वचे ॥’

इत्यनेन भास्करोक्त ऋतुवर्णनं निन्दितम् । वस्तुतः ‘सर्वत्र तन्नही’ति
कमलाकरोक्तं यथार्थमेव । परं पदज्ञान प्रकारोऽयं श्रीपत्युक्त इति कमलाकरेण
नोक्तः । सिद्धान्तशेखरस्याप्राप्तौ प्रकारोऽयं कमलाकरस्यैवेत्याधुनिका ज्योतिर्विदो
जानन्त आसन् । यदि रवेः पदज्ञानार्थं कोऽपि प्रकारः प्राचीनैर्यथार्थतो नोक्तस्तदा
प्रकारस्यास्य रचयिता श्रीपतिरवश्यमेव सर्वेषां ज्योतिर्विदां प्रशंसापात्रमित्यत्र
न कोऽपि सन्देहः । महादाश्रयं चैतद्यत् श्रीपतिकृतमिदं गोलयुक्तियुक्तं पदज्ञानं

त्यक्त्वा भास्कराचार्येण ऋतुवर्णनद्वारा पदज्ञानं समीचीनं ज्ञात्वा कृतमिति । चन्द्रग्रहणाध्याये रविचन्द्रभुवां योजनबिम्बानि, रविचन्द्रयोर्योजनात्मककर्ण-
स्पष्टीकरणां, भूभा बिम्बानयनं, ग्रासमानाद्यानयनं, परिलेखप्रकारश्चाचार्यैरुक्तः, श्रीपतिना भास्कराचार्येण च कथनक्रममादाय विशेषतया तथैवानूदितः । ब्रह्म-
गुप्तकृत एव सूर्यग्रहणाधिकारः श्रीपतिना प्रायः श्लोकान्तरैरुक्तः । उदयास्तमया-
ध्याये आयनदृक्कर्मसाधनं कृतं परं तन्न समीचीनं श्रीपतिनाऽपि प्राचीनोक्तं
तदानयनं कृत्वा—

खनभोषृतिभिः समाहृतं प्रथमं दृक्फलमायनाह्वयम् ।
द्युचराश्रितभोदयासुभिर्विहृतं स्पष्टमिह प्रजायते ॥

इत्यनेन तत्स्फुटीकरणं कृतं, एतदवलोक्य भास्कराचार्येण 'आयनं बल-
नमस्फुटेषुणा सङ्गुणमि' त्यादिना तदेवोक्तम् । चन्द्राध्याये ब्रह्मगुप्तेन बहवो-
विषयाः प्रतिपादिताः सन्ति, श्रीपतिना तु वराहब्रह्मगुप्तललाचार्याणां बहवः
श्लोका अनूदिताः । वस्तुतो नास्ति कश्चिद्विशेषः । केवलं चन्द्रस्य स्पष्टचरा-
नयने परिलेखसूत्रप्रमाणानयने च बहून्त्येव प्रकारान्तराणि स्फुटोक्त्या लिखि-
तानि सन्ति । वराहब्रह्मगुप्तललाचार्यैरुदयान्तरकर्म नोक्तं ग्रहयुत्यध्याये (ग्रह-
युद्धाध्याये-ग्रहयोगाध्याये वा)—

अन्त्यभ्रमेणगुणिता रविबाहुजीवाऽभीष्टभ्रमेण विहृता फलकार्मुकेण ।
बाहोः कलासु रहितास्ववशेषकं ते यातासवो युगयुजोः पदयोर्धनर्णम् ॥

इत्यनेन श्रीपत्युक्तं दृग्गणितैक्यकृत् कर्मैव भास्कराचार्येण उदयान्तर-
कर्मैति नाम्नोक्तम् । सिद्धान्तशेखरस्याप्राप्तौ भास्कराचार्येणैवानुभूतमिदं कर्म-
त्याधुनिकानां गणकानां प्रतीतिरासीत् । इदमुदयान्तरकर्म प्रथमं श्रीपतिरेव
स्वकीय विचारेण कथयामासेति ज्ञायते । तथा च—

त्रिभविरहितचन्द्रोच्चो न भास्वद्भुजज्या गगननृपविनिघ्नी भयत्रयज्या विभक्ता ।
भवति चरफलाख्यं तत्पृथक्स्थं शरघ्नं हृतमुडुपतिकर्णत्रिज्ययोरन्तरेण ॥१॥
परमफलमवाप्तं तद्धनर्णं पृथक्स्थे तुहिन किरणकर्णे त्रिज्यकोनाधिकेऽथ । स्फुट-
दिनकर हीनादिन्दुतो या भुजज्या-स्फुटपरमफलघ्नी भाजिता त्रिज्ययाऽऽप्तम् ॥२॥

शशिशिचरफलाख्यं सूर्यहीनेन्दुगोलात् तद्वर्णमुतधनं चेन्दूच्चहीनार्कगोलम् ।
यदि भवति हि साम्यं व्यस्तमेतद्विधेयं स्फुटगणितदृग्गैक्यं कर्तुं मिच्छद्भिरत्र ॥३॥

श्लोकत्रयेणानेन दृग्गणितैक्यार्थं श्रीपतिना चन्द्रे संस्कारविशेषो दत्तः ।
अस्मिन्पि प्राचीनग्रन्थे नायं संस्कारो लिखितो वर्तते । यद्यपि—

इन्द्रोच्चो नार्ककोटिधना गत्यंशा विभवा विधोः ।
 गुणो व्यर्कन्दुदोः कोट्योरूपपञ्चाप्तयोः क्रमात् ॥
 फले शशाङ्कतद्गत्यो लिप्ताद्ये स्वर्णयोर्वधे ।
 ऋणं चन्द्रे धनं भुक्तौ स्वर्णसाम्यवधेऽन्यथा ॥

इत्यनेनैतादृश एव चन्द्रसंस्कारो मुञ्जालाचार्येण 'लघुमानस'नामके
 करणग्रन्थे कथितः । परमेतयोः सहशत्वाभावात्—श्रीपतिना वेंधेन दृष्ट्वा ततो
 भिन्नोऽयं कथित इति प्रतिभाति । श्रीपत्युक्तोऽयं संस्कारो भास्कराचार्येणासकृद्-
 दृष्ट्वा विवेचितस्तत्र स्वोपलब्धेर्विस्तारपूर्वकं प्रतिपादनार्थमेको 'बीजोपनय'
 नामको ग्रन्थः ५९ श्लोकात्मकः सिद्धान्तशिरोमणि रचनैकवर्षान्तरं—

मयाय बीजोपनये यदन्ते सूर्योक्तमाद्यं परमं रहस्यम् ।
 प्रकाशये गोप्यमपीह देवं प्रणम्य बीजं जगतां हितार्थम् ॥१॥
 यद्यपि पूर्वमपीदं संक्षेपादुक्तमागमोक्तदिशा ।
 नैतावतैव कश्चित् दृक्करणैक्याय कल्पते गणकः ॥२॥
 दृक्करणैक्यविहीनाः खेटाः स्यूला न कर्मणामर्हाः ।
 अत इह तदर्हतायै तात्कालिकबीजविस्तरं वक्ष्ये ॥३॥
 पाता खेस्तामसकीलकाख्यास्तेषां समाकर्षणतः शशाङ्कः ।
 तत्तुङ्गशक्तिश्च निजस्वभावं विहाय नित्यं विषमत्वमेति ॥४॥
 चन्द्राच्च तद्योगवियोगतश्च साध्यं हि भाद्यं विषमं यतः स्यात् ।
 तस्माद्विधोऽत्र विशुद्धिशुद्धयै विस्तार्यते बीजफलक्रियेयम् ॥५॥
 एकेन पुंसा निखिलग्रहाराणामन्तं प्रबोधो नहि शक्यतेऽतः ।
 व्यासात्समासाच्च यथोपलब्धं प्रोक्तं मयेत्यादरणीयमेतत् ॥६॥

इत्यादिना सिद्धान्तशिरोमणिवद्भाष्यसहितो विरचित इति ।
 भग्नहयोगाध्याये—

कृत्वापि दृष्टिकर्म श्रीषेणार्यभटविष्णुचन्द्रोक्तम् ।
 प्रतिदिनमुदयेऽस्ते वा न भवति दृग्गणितयोरैक्यम् ॥१॥
 भमुनिमृगव्याधानां यतस्ततो दृष्टिकर्म वक्ष्यामि ।
 दृग्गणितसमं देयं शिष्याय त्रिरोषितादेयम् ॥२॥

इति ब्रह्मगुप्तेन पाण्डित्यपूर्णमुक्तम् । एतदेव यथार्थं बुध्वा तदुक्तो (ब्रह्म-
 गुप्तोक्तः) भग्नहयुत्यध्यायः सम्पूर्णोऽपि स्फुटोक्त्याऽनूदितः श्रीपतिनेति ।

ब्राह्मस्फुटसिद्धान्तोत्तरार्धे परिकर्मविंशतिः (सङ्कलितम्, व्यवकलितम्, प्रत्युत्तान्तो गुणनम् । भागहारः, वर्गः, वर्गमूलम्, घनः, घनमूलम् । पञ्चत्रायः, त्रैराशिकम्, व्यस्तत्रैराशिकम्, पञ्चराशिकम्, सप्तराशिकम्, नवराशिकम्, एकादशराशिकम्, भाण्डप्रति भाण्डं चेति) कथिताऽस्ति, सर्वत्रैव चतुर्वेदाचार्योक्ता उद्देशकाः (उदाहरणानि) सन्ति । सिद्धान्तशेखरेऽपि परिकर्मविंशतिः (अभिन्नाङ्कानां गुणन-भजन-वर्ग-वर्गमूल-घन-घनमूलानीति पट् ६, भिन्नाङ्कानां योगान्तर-गुणन-भजन-वर्ग-वर्गमूलानीति पट् ६, भाग प्रभाग-भागानुबन्ध-भागपवाहारव्यजाति चतुष्टयम् ४, विलोमकर्म १, त्रैराशिकम् १, व्यस्त त्रैराशिकम् १, पञ्चराशिकम् १, इति) ब्रह्मगुप्तश्रीपत्युक्तं विंशत्यां परिकर्मसु विषयवर्णने महानेव भेदोऽस्ति तद्विशतेः परिकर्मणां नामानि बहुधा भिन्नानि सन्ति । भास्करोक्त-प्रकीर्णविषयाः (सङ्कलिततो भाण्डप्रतिभाण्डं यावत्) यादृशाः स्फुटरूपेण वर्णिताः सन्ति न तादृशा ब्रह्मगुप्तश्रीपत्योः परिकर्मविंशत्युक्तविषयाः । विषयास्तु ब्रह्मगुप्तो-श्रीपत्युक्तौ-भास्करोक्तौ-समाना एव किन्तु तत्प्रति पादनरीनयो भिन्ना भिन्नाः सन्ति । एवमष्टौ व्यवहाराः (मिश्रक व्यवहारः, श्रेढी व्यवहारः, क्षेत्रव्यवहारः, खातव्यवहारः, चिति व्यवहारः, क्राकचिक व्यवहारः, राशिव्यवहारः, छायाव्यवहारः) ब्राह्मस्फुटसिद्धान्ते, सिद्धान्तशेखरे भास्करीय लीलावत्यां च सन्ति, एतेष्वष्टसु व्यवहारेष्वपि बहुधा न्यादृशत्वमस्ति, सर्वेषु व्यवहारेषु ब्रह्मगुप्तोक्तश्रीपत्युक्तव्यवहाराभ्यां भास्करोक्तव्यवहारेषु-विषयाधिक्यं-विषय-प्रतिपादनं स्फुटत्वं चास्ति, ग्रन्थत्रया (ब्राह्मस्फुटसिद्धान्तः, सिद्धान्तशेखरः, लीलावती च) बलोकनेनेति स्फुटं भवति, एतत्परं प्रश्नाध्यायोऽस्ति यत्र मध्यगत्युत्तराध्यायः, स्फुटगत्युत्तराध्यायः । त्रिप्रश्नोत्तराध्यायः । ग्रहणोत्तराध्यायः । शृङ्खलान्त्युत्तराध्यायः । एतेषु पञ्चसूत्रराध्यायेषु स्रोतराः प्रश्नाः सन्ति, प्रश्नाश्चातीव विलक्षणाः सन्ति, येषामभ्यासेन पाठका अतीव ज्योतिषसिद्धान्तविषयेषु-निपुणा भवितुमर्हन्ति प्रत्यध्यायमोदशः स्रोतरप्रश्नक्रमलेखः किञ्चित् किञ्चिद्वद्वेश्वर-सिद्धान्ते-सिद्धान्तशेखरे चावलोक्यते । सिद्धान्तशिरोमण्यादौ नायं क्रमोऽस्ति । एतत्परं प्रश्नसहितः कुट्टकाध्यायोऽस्ति, ब्रह्मगुप्तोक्तकुट्टकाध्याये^१ श्रीपत्युक्त-भास्करोक्ताभ्यां विषयाधिक्यमस्ति किन्तु विषयकथनस्फुटता भास्करोक्ता-वेवास्ति, घनणादीनां सङ्कलितव्यवकलितादि-भास्करोक्तवदेवास्ति-सिद्धान्त-शेखरेऽपि, ततः परमेकवर्णसमीकरणं बीजमस्ति, भास्करोक्तैकवर्णं समीकरणा-बीजतोऽल्पमेवास्ति । ततः परमनेकवर्णसमीकरणबीजमस्ति, ब्रह्मगुप्तमिदमपूर्व-

१. ब्रह्मगुप्तोक्त कुट्टकाध्याये बहवः प्रश्नास्तादृशाः सन्ति येषामुत्तरमतीवाऽऽनन्द-जनकमस्ति, येषामभ्यासेन पाठकास्तत्सम्बन्धविषयाणामतिज्ञातारो भवितु-मर्हन्तीति ।

मस्ति, अत्र विषयाश्चाप्यधिकाः सन्ति, भास्करोक्तमप्यनेकवर्णसमीकरणबीजं विषयाविक्रयेन सहितं विद्यते । किन्तु सिद्धान्तशेखरेऽतीव स्वल्पं तद्विद्यते । भाविज-बीजं ब्रह्मगुप्तोक्ताच्छ्रीपत्युक्तं स्वल्पं भास्करोक्तं चाधिकं विद्यते, सर्वत्रैव भास्करोक्तौ वैशद्यं वर्तते । एतत्परं वर्गप्रकृतिरस्ति, कनिष्ठे ज्येष्ठशेषाणां योगभावना-ऽन्तरभावना च ब्रह्मगुप्तोक्तादेवाऽऽदाय श्रीपतिना भास्करेण च विलिखिता, परं श्रीपतिना भावनास्वरूपं न प्रतिपादितम् । वर्गात्मकप्रकृतौ कनिष्ठज्येष्ठयो-रानयनं ब्रह्मगुप्तोक्तमेव बीजगणिते भास्करेण लिखितम् । परं श्रीपतिना तत्स-म्बन्धे किमपि न लिखितम् । शङ्कुच्छायादिज्ञानाध्यायो ब्रह्मगुप्तस्यापूर्वं वस्तु वर्तते सिद्धान्तशेखरे भास्करीय ग्रन्थे चैतदध्यायोक्ता विषया न सन्ति, वस्तुतो दर्शनीयोऽयमध्यायः । छन्दश्चित्युत्तराध्यायस्त्वेतादृशोऽस्ति, यत्रस्थश्लोकोपप-त्तीनां का कथा तद्व्याख्याऽप्यतिकठिना तेनैव हेतुनाऽद्यावधि तद्व्याख्योपपत्तिश्च कैरपि न लिखिता । गोलाध्याये-भूगोलसंस्थानं-देवासुरसंस्थानं-चक्रभ्रमण-व्यवस्थादेवादीनां रविभ्रमणस्थितिः, देवदैत्यानां राशिसंस्थानं-देवादोनां रवि-दर्शनकालः, भूगोले लङ्कावन्तीसंस्थानमित्यादयो विषयाः सन्ति —

भूपरिधितुर्यभागे लङ्काभूमस्तकात् क्षितितलाच्च ।

लङ्कोत्तरतोऽवन्ती भूपरिधेः पञ्चदशभागे ॥

इत्यनेन लङ्कोत्तरतो भूपरिधिपञ्चदशभागेऽवन्ती वर्तते इत्याचार्येण कथ्यते, आचार्यानुयायी भास्कराचार्यः सिद्धान्तशिरोमणेश्च गोलाध्याये 'निरक्षदेशात् क्षितिषोडशांशे भवेदवन्ती' इति कथितवान्, चतुर्वेदाचार्यसम्मतः पाठश्च 'पञ्च-दशभागे, अयमेव, अत्राध्याये-आचार्योक्ता बहवो विषयाः सूर्यसिद्धान्तीयभूगोला-ध्याये तथैव सन्ति, मध्ये मध्ये उभयत्र (आचार्योक्ताध्याये-सूर्यसिद्धान्तीय-भूगोलाध्याये) विषयान्तरारण्यपि सन्ति, सिद्धान्तशेखरस्य गोलाध्याये श्रीपति-नाऽपि कियन्तो विषया आचार्योक्तसदृशा एव कथिताः । 'यन्मूले तद्व्यासो मण्डललिप्ताकृतेर्दशहृतायाः' इत्यनेन परिधितो व्यासानयनं सूर्यसिद्धान्तोक्त 'तद्वर्गतो दशगुणात्पदं परिधिरित्यादेर्विलोमेन परिधितो व्यासानयनवदस्ति, श्रीपतिनापि 'कालः स्यात्परिधेर्वर्गाद्भिभक्ताच्च पदं त्विहे'ति प्रकारानुकूलैव त्रिज्या-तिथियुगाग्नि ३४१५ मिताऽस्तीति स्वीकृता भास्कराचार्येण 'व्यासे भनन्दाग्नि-हृते विभक्ते खवाणसूर्यः परिधिः सुसूक्ष्मः' इत्यनेन व्यासात्परिध्यानयनं कथ्यते । एतद्विलोमेन परिधितो व्यासानयनं भवेत् । परं केषामपि व्यासात्परिध्यानयनं परिधितो व्यासानयनं वा न समीचीनं तयोः (परिधिव्यासयोः) सम्बन्धस्या-स्थिरत्वादिति ।

ज्याप्रकरणे-आचार्येण यथा चापार्धांशज्याद्यानयनं कृतं तथैव सिद्धान्त-शेखरे श्रीपतिना सिद्धान्तशिरोमणेश्च गोलाध्याये भास्करेण च कृतमिति तदग्रन्थः

वलोकनात्स्फुटमस्ति । भास्करेण 'अन्त्यज्योत्पत्त्यौ' बहवो विशेषाः प्रतिपादिताः सन्ति ।

स्फुटगतिवासनायां—मन्दफलसाधनेऽपि कर्णानुपातेन यत्फलं तदेव समीचीनमिति कर्णः कथं न कृत इत्यस्य कारणम्—

त्रिज्याभक्तः परिधिः कर्णगुणो बाहुकोटिगुणकारः ।
असकृन्मान्दे तत्फलमाद्यसमं नात्रकर्णोऽस्मात् ॥

कथितम् । सिद्धान्तशेखरे—

त्रिज्याहृतः श्रुतिगुणः परिधिर्यतोदोः कोट्योर्गुणो मृदुफलानयनेऽसकृत्स्यात् ।
स्यान्मान्दमाद्यसममेव फलं ततश्च कर्णः कृतो न मृदुकर्मणि तन्त्रकारैः ॥

इति श्रीपत्युक्तश्लोक आचार्यो (ब्रह्मगुप्तो) क्त श्लोकस्यानुवादरूप एव,
भास्कराचार्येणापि—

स्वल्पान्तरत्वान्मृदुकर्मणीह कर्णः कृतो नेति वदन्ति केचित् ।
त्रिज्योद्घृतः कर्णगुणः कृतेऽपि कर्णो स्फुटः स्यात्परिधिर्यतोऽत्र ॥
तेनाद्यतुल्यं फलमेति तस्मात् कर्णः कृतो नेति च केचिदूचुः ।
नाशङ्कनीयं न चले किमित्थं यतो विचित्रा फलवासनाऽत्र ॥

इह कर्णेन यत्फलमानीयते तदेव समीचीनम् । यन्मन्दकर्मणि कर्णो न कृतस्तत्स्वल्पान्तरादिति कथ्यते । मन्दकर्मणि मन्दकर्णतुल्येन व्यासार्धेन यद्वृत्तं तत्कक्षावृत्तम् । तेन ग्रहो गच्छति । यो मन्दपरिधिः पाठपठितः स त्रिज्यापरिणतः । अतोऽसौ कर्णव्यासार्धे परिणाम्यते । यदि त्रिज्यावृत्तेऽयं परिधिस्तदा कर्णवृत्ते क इति स्फुटपरिधिः । ततः स्वेनाहते परिधिना भुजकोटिजीवे भांशैरित्यादिना यत्फलमागच्छति तत्त्रिज्यया गुणितं कर्णेन भक्तं यत्फलं तत्पूर्वफलतुल्यमेव फलमागच्छतीति ब्रह्मगुप्तमतम् । अथ यद्येवं परिधेः कर्णेन स्फुटत्वं तर्हि किं शोधकर्मणि न कृतमित्याशङ्क्य चतुर्वेदः कथयति—ब्रह्मगुप्तेनान्येषां प्रतारणपरिमिदमुक्तमिति । तदसत् । चले कर्मणीत्थं किं न कृतमिति नाशङ्कनीयम् । यतः फलवासना विचित्राऽस्तीति । अन्यत्सर्वं पूर्वकथितमेवेति ।

ग्रहणवासनायां—छादकनिर्णयं कृत्वा राहुकृतं ग्रहणं न भवतीति वराह-
मिहिरादीनां मतं प्रतिपाद्य संहितामतमवलम्ब्य तन्निराकृतम् ।

राहुकृतं ग्रहणद्वयमागोपालाङ्गनादि सिद्धमिदम् ।
बहुफलमिदमपि सिद्धं जपहोमस्नानफलमत्र ॥

लोक प्रथेयमिति कथयित्वा राहुकृतं ग्रहणं भवतीत्यत्र स्मृति वाक्यं वेदवाक्यं च प्रतिपादितम् । युक्त्वा राहुकृतं ग्रहणं न भवति । परन्तु स्मृतिषु-पुराणेषु वेदेषु च राहुकृतं ग्रहणं प्रतिपादितमस्त्यतोऽत्र द्वयोर्मतयोः समन्वयः—

राहुस्तच्छादयति प्रविशति यच्छुक्लपञ्चदश्यन्ते ।
 भूछाया तमसीन्दोर्वरप्रदानात् कमलयोने ॥
 चन्द्रोऽम्बुमयोऽधःस्थो यदग्निमयभास्करस्य मासान्ते ।
 छादयति शमिततापो राहुश्छादयति तत् सवितुः ॥

आचार्येण कृतः । सिद्धान्तशिरोमणौ गौलाध्याये भास्कराचार्येण भूभाकृतं चन्द्रग्रहणम् । चन्द्रकृतं सूर्यग्रहणं प्रतिपाद्य स्मृतिपुराणादिमतेन साकं समन्वयार्थ—

राहुः कुभामण्डलगः शशाङ्कं शशाङ्कगच्छादयतीव बिम्बम् ।
 तमोमयः शम्भुवरप्रदानात्सर्वागमानामविशुद्धमेतत् ॥

इति कथितम् । सिद्धान्तशेखरे राहुकृतग्रहणखण्डनार्थमेको 'राहुनिराकरणाध्यायः' नामकोऽध्यायोऽस्ति । 'गोलबन्धाधिकारे महद्वृत्तानां (पूर्वापरवृत्त-याम्योत्तरवृत्त क्षितिजवृत्तादीनां) लघुवृत्तानां (मेषादिद्वादशराशीनामहोरात्र-वृत्तानि) रचनां विधाय परमलम्बनावन्त्योः स्वरूपं प्रतिपाद्य दृक्कर्मनयनं कृत-माचार्येण, यथाऽत्र ब्राह्मस्फुटसिद्धान्ते ब्रह्मगुप्तेन गोलबन्धः प्रतिपादितस्तथैव सिद्धान्तशिरोमणौ चास्ति । ग्रहर्क्षगोलयोः पञ्च स्थिरवृत्तानि (पूर्वापरम्, याम्योत्तरम्, क्षितिजम्, उन्मण्डलम्, बिषुवन्मण्डलम्) इति प्रतिपादितानि, एतानि कक्षामण्डलतुल्यानि महद्वृत्तानि ज्ञेयानि । ग्रहाणां चलवृत्तानि च—

मन्दनीचोच्चवृत्तानि = ७, भौमादीनां शीघ्रनीचोच्चवृत्तानि = ५ । मन्द-प्रतिवृत्तानि—७, शीघ्रप्रतिवृत्तानि = ५ दृग्क्षेपमण्डलं, दृक्क्षेपमण्डलं कक्षामण्डलं

१. सिद्धान्तशेखरे सूर्यचन्द्रयोर्ग्रहणयोराहोरकारणत्वेऽपि लोकमतश्रुति स्मृति संहि-
 तानां दथैक्यं भवति तथा तत्प्रतिपादनाय राहोरेव ग्राहकत्वं कथ्यते यथा—

विष्णुलूनशिरसः किल पङ्कोर्दत्तवान् वरमिमं परमेष्ठी ।
 होमदानविधिना तव तृप्तिस्तिग्मशीतमहोसपरारणे ॥
 भूमेच्छायां प्रविष्टः स्थगयति शशिनं शुद्धलपक्षावसाने ।
 राहुर्ब्रह्मप्रसादात् समधिगतवरस्तत्तमो व्यासतुल्यः ॥
 ऊर्ध्वस्थं भानुबिम्बं सलिलमयतनोरप्यधोवर्त्ति बिम्बं
 संसृत्यैवं च मासव्युपरतिसमये स्वस्य साहित्यहेतोः ।

चेति सप्तानां ग्रहाणाम्=२१, चन्द्रादीनां विमण्डलानि=६ सर्वेषां योगश्चल-
वृत्तान्येक पञ्चाशत् सन्तीति, सिद्धान्त शेखरेऽप्येवमेवास्ति यथा—

मन्दोच्चनीचवलयानि भवन्ति सप्त शैथ्याणि पञ्च च तथा प्रतिमण्डलानि ।
दृक्क्षेप दृष्टचपमजानि च खेचराणामर्कं विनैव खलु पट् च विमण्डलानि ॥
पञ्चाशदेकसहितानि च मण्डलानि पूर्वापरं वलयमुत्तरदक्षिणं च ।
क्षमाजं तथा विषयदुद्वलयाभिधाने पञ्च स्थिराणि कथितान्युदु खेचराणाम् ॥

इति यन्त्राध्याये—

सप्तदश कालयन्त्राण्यतो धनुस्तुर्यगोलकं चक्रम् ।
यष्टिः शङ्कुर्घटिका कपालकं कर्त्तरी पीठम् ॥
सलिलं भ्रमोऽवलम्बः कर्णच्छाया दिनार्धमर्कोऽक्षः ।
नतकालज्ञानार्थं तेषां संसाधनान्यष्टौ ॥

इत्यने धनुर्यन्त्रम् । तुरीयम् । चक्रयन्त्रम् । यष्टिः, शङ्कुः, घटीयन्त्रम् ।
कपालयन्त्रम् । कर्त्तरीयन्त्रम् । पीठसंज्ञं यन्त्रम् । सलिलं (जलम्), भ्रमः (शाराः),
अवलम्बसूत्रम्, छायाकर्णः, शङ्कुच्छाया, दिनार्धमानम्, सूर्यः, अक्षः (पलांशाः)
नतकालज्ञानार्थं सप्तदश काल यन्त्राणि सन्ति, तेषां यन्त्राणां मध्ये सलिलादीन्यष्टौ
यन्त्ररचना मूलकानि सन्ति, सिद्धान्तशेखरे 'गोलश्चक्रं' कामुर्कां कर्त्तरी च कालज्ञाने
यन्त्रमन्यत् कपालम् । पीठं शङ्कुः स्याद् घटी यष्टिसंज्ञं गन्त्री यन्त्राण्यत्र दिक्
सम्मितानी' त्युक्तं १ गोलयन्त्रम्, २ चक्रयन्त्रम्, ३ धनुर्यन्त्रम् । ४ कर्त्तरी नामक-
यन्त्रम् । ५ कपाल यन्त्रम् । ६ पीठ (फलक) यन्त्रम्, ७ शङ्कुनामकयन्त्रम् ।
८ घटीनामक यन्त्रम्, ९ यष्टि यन्त्रम् । १० गन्त्री (शकट) यन्त्रम् । इति दश-
मितानि यन्त्राणि श्रीपत्युक्तानि सन्तीति । शिष्यधीवृद्धिद तन्त्रेद्वादश यन्त्रा-
ण्युक्तानि यथा—

गोलो भगणश्चक्रं धनुर्घटी शङ्कुशकटकर्त्तर्यः ।
पीठकपालशलाका द्वादश यन्त्राणि सह यष्टिधा ॥
कर्णच्छाया द्युदलं रविरक्षो लम्बको भ्रमः सलिलम् ।
स्युर्यन्त्रसाधनानि प्रज्ञा च समुद्यमाश्चैवम् ॥

भास्कराचार्येण सिद्धान्त शिरोमणौ दशैव यन्त्राण्युक्तानि । यथा—

गोलो नाडीवलयं यष्टिः शङ्कुर्घटी चक्रम् ।

चापं तुर्यं फलकं धीरेकं पारमार्थिकं यन्त्रम् ॥ इति ।

सूर्य सिद्धान्तोक्त यन्त्राणि—

तुङ्गबीजसमायुक्तं गोलयन्त्रं प्रसाधयेत् ।
 गोप्यमेतत्प्रकाशोक्तं सर्वगम्यं भवेदिह ॥
 कालसंसाधनार्थाय तथा यन्त्राणि साधयेत् ।
 एकाकी योजयेद्वीजं यन्त्रे विस्मयकारिणि ॥
 शङ् कुयष्टिधनुश्चक्रं दृष्ट्वायायन्त्रै रनेकधा ।
 गुरूपदेशाद्विज्ञेयं कालज्ञानमतन्द्रितैः ॥
 तोययन्त्रकपालाद्यैर्मयूरनरवानरैः ।
 ससूत्ररेणुगर्भैश्च सम्यक् कालं प्रसाधयेत् ॥
 पारदाराम्बुसूत्राणि शुल्बतैलजलानि च ।
 बीजानि पांसवस्तेषु प्रयोगास्तेऽपि दुर्लभाः ॥
 ताम्रपात्रमधश्छिद्रं न्यस्त कुण्डेऽमलाम्भसि ।
 षष्टिर्मज्जत्यहोरात्रे स्फुटं यन्त्रं कपालकम् ॥
 नरयन्त्रं तथा साधु दिवा च विमले रवौ ।
 छाया संसाधनैः प्रोक्तं कालसाधनमुत्तमम् ॥

मानाध्याये—

मानानि सौरचान्द्राक्षसावनानि ग्रहानयनमेभिः ।
 मानैः पृथक् चतुर्भिः संव्यवहारोऽत्र लोकस्य ॥

इत्यनेन सौरचान्द्रनाक्षत्रसावनमानानि कथितानि, एभिरेव चतुर्भिर्मानैर्लोकानां व्यवहारा भवन्ति । केन केन मानेन के के पदार्था गृह्यन्ते इति सर्वे प्रतिपादिताः सन्ति, ब्राह्मं, दिव्यं, पित्र्यं, प्राजापत्यं, बार्हस्पत्यं, सौरं, सावनं, चान्द्रं, नाक्षत्रमिति नव मानानि सन्ति, एतेषु नवमानेषु मनुष्यलोके मानचतुष्टयानां (सौरचान्द्राक्षसावनानां) प्राधान्यम्, यतस्तैरेव तेषां व्यवहारा दृश्यन्ते । सूर्यसिद्धान्त-सिद्धान्तशेखर-सिद्धान्तशिरोमण्यादिषु सर्वेषु ग्रन्थेषु मानानां सम्बन्धे समानरूपेणैव सर्वं प्रतिपादितमस्ति । ब्राह्मस्फुटसिद्धान्तेऽत्राध्याये भूभादैर्घ्यं भूभामानञ्चापि प्रतिपादितमस्ति ।

संज्ञाध्याये—संज्ञाकथनकारणम् । सिद्धान्त एक एवास्ति, कस्मिन्नंशे सूर्यसिद्धान्तादयो भिन्नाः सन्तीति प्रतिपाद्य स्वसिद्धान्तोत्तरार्धेऽनुक्रमशः कथिता आचार्येण, नान्येषु-सूर्यसिद्धान्त-सिद्धान्तशेखरादिसिद्धान्तग्रन्थेषु संज्ञाध्यायः । अध्यायोपसंहारात्पूर्वमेकः प्रश्न विशेषः—

आग्नेये नैऋत्ये वेष्टदिने संस्थितस्य योऽर्कस्य ।

शङ्कुच्छाये कथयति वर्षादपि वेत्ति सूर्य सः ॥

कथितोऽस्ति यदुत्तरं कोणाशङ्कोरानयनेत स्फुटमस्ति ।

संज्ञाध्यायकथनस्य किमपि प्रयोजनं नासीत् ॥

आचार्येण कथमेतस्याध्यायस्योत्पत्तिः कृत इति न जानीमः ।

ध्यानग्रहोपदेशाध्याये—चैत्रादौ मासगणानयनम् । चैत्रादौ दिनादिकं तिथि ध्रुवसाधनम् । इष्टमासादौ रव्यानयनम् । प्रतिमासं शशिकेन्द्रतिथिध्रुवक्षेपयोगानयनम् । प्रतिदिनचालनम् । चन्द्रसाधनमौदधिकरविसाधनञ्च । ज्याखण्डकानि केन्द्रज्या साधनञ्च यथा —

त्रिशत् सनवरसेन्दुर्जिनतिथिविषया गृहार्धचापानाम् ।

अर्धज्याखण्डानि ज्याभुक्तैक्यं स भोग्य फलम् ॥

गतभोग्यखण्डकान्तरदलविकलवधाच्छतैर्नवभिराप्तैः ।

तद्युतिदलं युतोनं भोग्यादूनाधिकं भोग्यम् ॥

इत्याचार्योक्तभोग्यखण्डस्पष्टीकरणमेव सिद्धान्तशिरोमणोर्ग्रहगणिनाध्यायस्य स्पष्टाधिकारे 'धातैष्ययोः खण्डकयोर्विशेषः शेषांशनिघ्नः' इत्यादिना भास्कराचार्येण कथितम् । भास्कराचार्येण खार्क-१२० मिता त्रिज्या गृहीता, अत्राचार्येण खतिथि १५० मिता त्रिज्या गृहीता । इत्यतीववैचित्र्यं यत्सर्वत्रैव श्रीपतिनाऽऽचार्यश्लोकोक्तविषया एव छन्दोन्तरेण लिखिताः परं किं कारणं यदपूर्वं भोग्यखण्डस्पष्टीकरणं न लिखितम् । चन्द्रभुजफलसंस्कारः, तिथौ फलसंस्कारश्च । इत्यादयः सर्वे विषया अपूर्वाः सन्ति । अत्राध्याये ये केचन विषया लिखिताः सन्ति ते सूर्यसिद्धान्ते सिद्धान्तशेखरे, सिद्धान्तशिरोमणी न सन्ति ।

अनुगृहीतोऽस्म्यहं श्रीडाक्टर सत्यप्रकाश डी० एस० सी० महोदयानां यैराङ्गलभाषायां कृपया ग्रन्थस्यास्य प्रस्तावनां समरचि ।

सम्पादकमण्डलस्यान्ये सहयोगिनः ज्योतिषाचार्याः श्रीमुकुन्दमिश्राः, श्रीविश्वनाथ झा, श्रीदयाशंकरदीक्षिताः, शास्त्रिणः श्रीओदतशर्माणश्च सर्वे एव मम धन्यवादस्य पात्रतामर्हन्ति । एतेषाममूल्यसहयोगेनैवायं महान् ग्रन्थः सुचारुरूपेण सम्पूर्णतामगच्छत् ।

'पद्मश्रीप्रकाशनालयस्य' स्वामिने रमेशचन्द्रशर्मणोऽपि धन्याञ्जलिर्भवतु यस्य महता परिश्रमेण ग्रन्थस्य प्रकाशनं कालेनैवाभवत् ।

अन्येभ्यः सर्वेभ्योऽपि धन्यवादान् प्रददे, यैरल्पमपि साहाय्यं विधायाहं कृतार्थीकृतोऽस्मि, इति शम् ।

भृगु-आश्रमः }
३०-३-६६ }

विदुषामनुचरः
रामस्वरूप शर्मा

श्रीब्रह्मगुप्ताचार्य विरचितः
विभिन्नपाठान्तरसहितो

ब्राह्मस्फुटसिद्धान्तः ७

Astronomy in Ancient Nations

Brahmagupta's great works like the *Khaṇḍakhadyaka* and the *Brāhma-sphuṭa-siddhānta* took astronomy to Arabs through whom it spread to many countries of Europe. Al Beruni records this testimony in his great book on India. It is doubtful that astronomy had its birth in Greece and China. From remote ages China, India, Greece, Arabia and Egypt developed the entire system in close cooperation. This knowledge must have spread from their common cradle home where man for the first time developed his culture and civilisation. In this chapter we propose to give a review of astronomy as developed in many of these ancient lands, especially Arabia, people of which land came in close contacts with India much before any recorded time.

Dawn of Astronomy

The earliest man must have been the primitive astronomer. The striking spectacles presented to him by the varied appearances of a sky covered with thousands of twinkling and non-twinkling objects of different degrees of brightness, apparently revolving round the Earth, and the daily changing phases of the Moon must have raised strange feelings of the most primitive man also. Then he must have in course of time observed the bright morning and evening stars, and at a considerably late stage the comets and shooting stars and then on occasions eclipses of the Sun and the Moon. These phenomena not only raised feelings of admiration, but in different sections of human society often feelings of superstitious alarm. By and by stars became guides for the traveller by land and sea. In the midst of these observations, one discovered various cycles: cycle of day and night, cycle of seasons and cycle of other details. Then there was a striking observation of the tides in a sea changing with the phases of the Moon.

Earliest Discoveries

We shall briefly sketch out the order of astronomical discoveries. The first phenomena to be noted must have been the regularly recurring dawn (for this one may refer to the Uṣā Sukta of the *R̥gveda*), the sunrise and sunset (which led to *prataḥ* and *sāyam*, i.e. morning and evening prayers of the Vedic times), daylight, twilight and night concerning which we have numerous Vedic hymns. Next it led to the measurement of a day (which was of a short duration in winters and of a long duration in summers). The Vedic Aryans also discovered the variations in the duration of the day along different latitudes, and the time of sunrise in places of different longitudes. In fact the idea of longitudes and latitudes came sufficiently afterwards. Man discovered month as related to the variation of light with the Moon's phases. In temperate regions, where probably the first astronomical observations were systematically made, the changing length of the day or the direction of the Sun at rising or setting or the lengths of shadows cast at midday, would show that the Sun's daily path in the sky altered throughout the year, a time interval which was already marked by the changing vegetation. According to Sir W.C. Dampier, "attempts were made to determine the number of months in the cycle of the seasons in Babylonia about 4000 B. C. and in the China soon after. About 2000 B. C. the Babylonian year settled down to one of 360 days or twelve months, the necessary adjustments being made from time to time by the interposition of extra-months." In India, this concept is of even much earlier origin. The old inspired sages like Dīrghatamas discovered for the observing man the Vedic Era and intercalation. I have described this discovery in a special chapter on the subject in my book the *Founders of Sciences in Ancient India* and a reference may be made to the *Āśya Vāmasya Suktam* of the *R̥gveda*. It is impossible to assign an age to these old traditions. Round the *Yajña*, developed the science of astronomy, mathematics, anatomy and medicine in this ancient land of ours, which in fact was the common heritage of a large number of people of the modern world.

One might also say that a considerable period might have well elapsed before it was noticed that at a particular season of

the year, the same stars are seen at corresponding hours of the night. Of course this circumstance was less conspicuous than the regular variation of the Sun's altitude in the sky as the year progresses. It is the surmise that the striking naked-eye cluster, the Pleiades, must have been one of the earliest noted star-groups, and it became the first star-group for providing the first fairly close determination of the length of the year as approximately 365 days. The rising of this cluster in the evening was a mark of the coming winter to primitive man; and the husbandman judged the time of reaping by its rising, and of ploughing by its setting in very ancient times; Sirius, Arcturus, the Hyades and Orion were similarly equally useful to him. The passages in the *Taittiriya Samhitā* and in the *Śatapatha Brāhmaṇa* clearly indicate the confusion once created by following the concept of lunar months without further adjustments:

"Now the seasons were desirous to have a share in the sacrifice among the gods and said, 'Let us share in the sacrifice. Do not exclude us from the sacrifice! Let us have a share in the sacrifice!' The gods, however, did not approve of this. The gods, not approving, the seasons went to the Asuras, the malignant, spiteful enemies of the gods. Those (Asuras) then throve in such a manner that they (the gods) heard of it, for even while the foremost (of the Asuras) were still ploughing and sowing, those behind them were already engaged in reaping and threshing: indeed even without tilling, the plants ripened forthwith for them. (ŚBr. I.6.1.1-3)

The Zodiac

It is difficult to say how much time it must have taken, but in fact, it was eventually noted that the Sun and Moon travel over very similar paths among the stars during their circuit of the sky. This led to the formation of the Zodiac and its constellations, the centre of this zone, a belt about 16° broad, being the annual path of the Sun or Ecliptic. The division into twelve parts, each corresponding to a month of the Sun's movement, was made; and their connection with the solar course during the year was found by observations of heliacal risings or settings. These were the times of the year when certain bright stars would first be seen to rise before the Sun, or when

they were last seen to set after sunset. In the case of *Śirius*, the brightest fixed star, these would happen when the Sun was about ten degrees below the horizon. For the less bright stars the angle would be a larger one.

It must have been almost simultaneously observed that the Moon in going like the Sun round the heavens always in the same direction from west to east (i. e., opposite to the diurnal motion which she shares with the other bodies), kept in general to the same track in the sky. After a time, however, it must have been noted by careful observers that this path was not constant, but deviated from the centre line of the Zodiac, getting away from that line up to a maximum deviation on either side but slowly returning to it. In the course of a number of years, it must have become evident that the Moon's path among the stars does not lie always in the same line on the celestial sphere, but in a zone or band about twenty moon breadths (10°) wide, occupying the middle of the Zodiacal zone itself.

Among the bright stars Mercury, Venus, Mars, Jupiter and Saturn (the first two of which are never seen very far from the Sun in the sky) soon must have been noted to be moving in the Zodiac with varying periods. The English name *planet* is derived from Greek *planetes*, meaning a wanderer, since the planets change their positions among the Zodiacal stars.

There is a word *Str* which in the *R̥gveda* always occurs in the instrumental plural, *Str̥bhiḥ*. The English word star is derived from this word. Parāśara and Ṛtsamada, I have shown elsewhere, were the first amongst the great observers, inspired by the *R̥gvedic* hymns, and Vāmadeva identified *Bṛhaspati* or the Jupiter planet and Vena *Bhārgava* discovered the planet Venus which still bears the name of its discoverer.

Constellations

Long before the Zodiacal belt was divided into "signs" (700 B. C.), a number of asterisms, or the configuration of stars in the sky had been arranged, the brighter stars of these configurations, thus identified, proved very useful in indicating the seasons of the year by the times of their rising or setting, and also in locating the positions on the celestial vault of such moving objects as planets, comets and shooting stars and in helping the traveller by land or sea to determine direction.

These named constellations date back to very early period. In India, Gārgya is the name of an astronomer who is associated with a hymn of the *Atharvaveda* which for the first time enumerates constellations. In many of these constellations, the stars form a well marked group, clearly separated from other groups, and the names given to these formations are supposed to have been suggested by a resemblance to the shapes of certain familiar objects. Of course, the resemblance is usually very slight, and depended merely on a fancy.

It is remarkable that different countries developed almost similar notions regarding these constellations. The late Dr. A. C. D. Crommelin considered that there is a reason to believe that the stars may have been grouped to some extent by the Egyptians as early as 4000 B. C., and he remarked on their use of the then Pole Star for orienting the Great pyramid. Again, Chinese are said to have mapped out the sky into many divisions of stars by 2500 B. C., if one can rely on their records.

The idea of constellations takes us to a date much earlier than 2500 B. C. even. In total forty-eight have come down from extremely ancient times, but these do not cover the entire extent of the sky. The part not occupied by any of them evidently did not rise above the horizon where the early astronomers to whom we owe their naming lived; and the stars concerned were therefore not included in their constellation schemes. The centre of this part (near the bright star Achernar) must have been near the South Pole of the heavens of the time, and its angular radius from the Pole gives us roughly the latitude of their homes. The date appears to have been about 2800 B. C., when, owing to the precession of the equinoxes, the South celestial pole was in the position indicated. The latitude seems to have been about 38° North. These are the findings of E. W. Maunder (*Astronomy without a Telescope*, p.5, 1902); but from the same considerations Dr. Crommelin assigns a latitude of 36° and a date 2460 B.C., and Proctor 2200 B. C. Maunder also suggested that the presence of the Lion and Bear among the stellar configurations and the absence of Elephant, Tiger, Camel and Crocodile seem to exclude India towards the East and the countries towards the West, the latitude and the longitude indicated being those of Asia Minor or Armenia. The suggestion that the blank area in

the sky referred to gave an approximate date for the formation of the constellations appears to have been first put forward in 1807 by Carl Schwartz, for some time Swedish Consul at Baku.¹

Indo-Greek Contacts

It is highly improbable that before Alexander, there had been absolutely no contacts between India and the distant nations. Even in pre-Alexandrian era, there had been such migration is clearly evinced by the philological and mythological studies. But we do not possess historic record of it.

The conquests of Alexander the Great made the Greeks acquainted with the Eastern world, which had up to that time been visited probably by very few Europeans, and it likewise spread Greek culture to all the countries which the victorious Macedonian had been able to reach. The Indian province of his Empire became independent soon after Alexander's death, and though the spread of Buddhism in the third century B. C. checked the progress of Hellenism in Northern India, the rise of the Greek kingdom of Bactria and its gradual extension south and east continued for a long time to keep alive the connection between India and the West. Not only (as has been asserted) the Greek and Indian drama and architecture have been strongly influenced by Hellenistic and Indian contacts, it is beyond a doubt that the entire astronomy of the two great nations is the offspring of these mutual contacts.

In earliest times astronomy had only been cultivated in India and in no other country. Some idea had been acquired during those days of the periods of the Sun and Moon and the planet Venus and Brhaspati (Jupiter), which were used for chronological purposes, the lunar motions being specially connected with the proper times for sacrificial acts. The Vedic era was discovered during this period by Viśvāmītra, and Gārgya enumerated the Nakṣatras. Lagadha composed his *Vedāṅga Jyotiṣa*, which is the first book on astronomy written in human literature. India developed her geometry in connection with the construction of sacrificial altars, and its account is found in the *Śulba Sūtras* of Baudhāyana, Āśvalāyana and Kātyāyana. Āryabhaṭa laid the foundations of algebra. One might still say that there is no sign of

1. See, Peter Doig: *A concise History of Astronomy*, London, 1950.

accurate knowledge of the planetary motions earlier than about the century of the Christian era. From thenceforth astronomy, hitherto confined to rituals, appears as a science, treated in the course of the next thousand years in a series of text-books, the *Siddhantas*,¹ the contents of which, though supposed to be derived from divine sources are strongly influenced by Greek authors. Prior to the Greek influence, we had ceremonies like *dvādaśāha* (lasting for twelve days), *ṣaḍāha* (lasting for six days), *tryāha* (lasting for three days) besides *darśa-pūrṇamāsa* ceremonies connected with the New Moon and Full Moon. But the week of seven days (*Saptāha*) was unknown in India. This concept of week and the dedication of each day to the deity of one of the seven planets, now appears for the first time. It is difficult to say whether names of the planets were borrowed by Greeks from India or vice versa, but they became common, e.g., *Aśvajit* or *Asphudit* (Aphrodite), *Dyugatiḥ* or *dyaus* or *Jīva* (Zeus), *Heli* (Helios), &c., while the zodiacal signs have superseded the earlier but totally different twelve star-groups connected with the Sun's motion, and proclaim their origin by their names:

Kriya, Tāvuri, Jituma, Karkin, Leya, Pāthēna, Jūka, Kaur-pya, Taukshika, Ākokerā, Hridroga, Ittha,

corresponding to *Κριός, Ταῦρος, Δίδυμος, Καρκίνος, Λέων, Παρθένος, Ζυγόν, Σκορπίος, Τοξότης, Αιγόκερως, Ἰδρόχος, Ἰχθύς*.

A great many other Greek terms connected with geometry, astronomy and astrology have also been transferred from Sanskrit works to Greek and vice versa. This conclusively shows the mutual influence on astronomy. Indian authors never failed to acknowledge the ideas they borrowed from Greeks, e.g. Varāhamihira quotes the Yavanas or peoples of the west as authorities for some of the scientific statements he makes. The name of the *Romaka Siddhānta* (which is at least as old as A.D. 400) also points in an unmistakable manner to its origin in one of the provinces of the Roman Empire.

1. The *Romaka* or *Paulīśa Siddhānta* (before 400 A. D.), See Varāhamihira's the *Pañcasiddhāntikā* (about 570 A.D., Varāhamihira died in 587 A.D.). The original *Sūrya-siddhānta* was prior to Varāhamihira, the modern edition is perhaps of the 13th century. See J. Burgess "Notes on Hindu Astronomy," J. R. A. S., October 1893, p. 742.

Earth as a Sphere

The astronomers of the *Siddhāntas* taught that the Earth is a sphere, unsupported in space, and they reject the ancient mythological notion that it is supported by some animal like śeṣanāga (serpent), kacchapa (tortoise), or diggajas (elephants) which in turn rest on another, and so on, until the support of the last one after all has to be left unexplained. Bhāskara II, about A.D. 1150, who comments on the absurdity of this, also rejects the idea that the Earth is perpetually falling, since it would fall faster than an arrow shot upwards, on account of being heavier, so that an arrow could never again reach the Earth.¹ Round the Earth the planets are moving, all with the same linear velocity. The diameter of the Earth is 1600 yojanas, the distance of the Moon is 51,570 yojanas (or 64.5 times the radius of the Earth, nearly equal to Ptolemy's greatest distance, $64\frac{1}{2}$), while the distances of the other planets result from the assumption of equal velocities.² The equation of centre of the planets is found by an epicycle and to this arrangement the Hindus add one of their own invention, by assuming that the epicycle had a variable circumference, greatest when the planet is at apogee or perigee and least at 90° from these, when the equation reaches its maximum. This contrivance of an oval epicycle was by some astronomers applied to all the planets, by others (Brahmagupta and Bhāskara) only to Mars and Venus, by others it was altogether rejected.³ Why they complicated the calculation in this way is not clear. Āryabhaṭa I of Kusumapura or Pāṭaliputra, born A.D. 476, made another deviation from the Alexandrian doctrines, as appears in the *Brāhma-sphuṭa-siddhānta* of Brahmagupta, wherein he quotes the following from Āryabhaṭa: "The sphere of the stars is stationary, and the Earth, making a revolution, produces the daily rising and setting of stars and planets." Brahmagupta rejects this idea, saying: "If the Earth moves a minute in a prāṇa, then whence and what route does it proceed? If it revolves, why do not lofty objects fall?" But his commentator Caturveda Pṛthudaka Svāmi replies: "Āryabhaṭa's

1. *As. Res.* XII. p. 229 (*Essays*, II, p. 394).

2. The distances are proportional to the orbital periods of revolution, but for Mercury and Venus to the periods in the epicycles.

3. For further details see *As. Res.* II. p. 251 (Davis) and XII. p. 236 (Colebrooke, also *Essays*, II, p. 401).

opinion appears nevertheless satisfactory, since planets cannot have two motions at once : and the objection, that lofty things would fall, is contradicted; for every way the under part of the Earth is also the upper; since wherever the spectator stands on the Earth's surface, even that spot is the uppermost spot.¹

Earth rotation by a current of aerial fluid

It is very interesting to see the theory once advocated by Herakleides of Pontus transplanted on Indian soil, especially when we remember that Seleukus, the Babylonian, had adopted that theory. From Babylon the theory might easily find its way to India, though it is of course equally possible that Āryabhata, quite independently of his Greek precursors, hit on the same idea. He appears to have accounted for the Earth's rotation by a wind or current of aerial fluid, the extent of which, according to the orbit assigned to it by him, corresponds to an elevation of little more than a hundred miles (114) from the surface of the Earth, or fifteen *yojana*'s while he put the diameter of the Earth equal to 1050 *yojanas* (of 7.6 miles each²). This was in accordance with the general opinion of the Indians, that the planets are carried along their orbits by mighty winds with the same velocity and parallel to the ecliptic (while one great vortex carries all stars round the Earth in twenty-four hours, but that the planets are deflected from these courses by certain invisible powers having hands and reins, with which they draw the planets out of their uniform progress. The power at the apogee, for instance constantly attracts the planet towards itself, alternately with the right and left hand (like Lachesis in Plato's *Republic*), while the deity at the node diverts the planet from the ecliptic first to one side and then to the other. And lastly the deity at the conjunction causes the planet to move with variable velocity and to become occasionally stationary and even retrograde. This is gravely set forth in the *Sūrya-siddhānta*, and even Bhāskara gives the theory in his notes, though he omits it from his text. Similarly Brahmagupta, although he gives the theory of eclipses, affirms the existence of an eighth planet, Rāhu, which is the immediate cause of eclipses; and he blames Varāhamihira,

1. *Asiat. Res.*, XII, p. 227; Colebrooke's *Essays*, II, p. 392.

2. Colebrooke, *Notes and Illustrations to the Algebra of Brahmagupta*, p. xxxviii. *Essays*, II, p. 467.

Āryabhata and others for rejecting this orthodox explanation of the phenomenon.¹

Indian astronomy some times appears to be a curious mixture of old fantastic ideas and sober geometrical methods of calculation. But it is wrong to presume that these geometric calculations were derived from foreign contacts. Indians have always been fond of geometry (from the earliest times of the Vedic rituals), and they from the very beginning realised the importance of applying geometry to astronomy. Side by side we find Greek contacts also. As remarked by Colebrooke, the absence of the most characteristic parts of Ptolemy's system, the equant and the details of the theories of the Moon and Mercury seems to indicate that Greek planetary theory must have been introduced in India between the times of Hipparchus and Ptolemy; and with the exception of the epicycle from the circular form, the Hindus did not modify the theory or perfect it in any way. The precession of the equinoxes they held to consist in a liberation within the limits of 27° (Āryabhata says 24°) east and west of its mean position, but they came much nearer to the truth than Ptolemy did as regards the annual amount, as they supposed the space travelled over in a century to be $1\frac{1}{2}^\circ$.

Contacts with Arabs

Notwithstanding some isolation of India from Europe during the Middle Ages, her astronomy was destined to exercise an indirect influence on the progress of astronomy. Through the conquest of Persia in the seventh century, the Arabs, like the Greeks a thousand years earlier, came in contact with India, from whence physicians and astrologers found their way to the court of the Caliph already before the reign of Harun al Rashid. We possess a detailed account of the manner in which the Indian astronomy was introduced at Baghdad, from the pen of the astronomer Ibn al Adami (who died before 920), confirmed by the celebrated memoir on India by Al Beruni, written in 1031². In the year 156 of the Hijra (A. D. 773), there appeared before the Caliph Al Mansur a man who had come from India; he was skilled in

1. *Asiat. Res.* XII, pp. 233, 241; *Essays*, II, pp. 398, 407.

2. Hankel, *Zur Geschichte der Mathematik im Alterthum und Mittelalter*, Leipzig, 1874, p. 229; Cantor, *Gesch. d. Math.* I, p. 656.

the calculus of the stars known as the *Sindhind* (i. e. *Siddhānta*), and possessed methods for solving equations founded on the *kardagas* (i. e. *kramajyā*, sines) calculated for every half degree, also methods for computing eclipses and other things. Al Mansur ordered the book in which all this was contained to be translated into Arabic, and that a work should be prepared from it which might serve as a foundation for computing the motions of the planets. This was accordingly done by Muhammed ben Ibrahim Al Fazari, whose works the Arabs call the great *Sindhind*, and from it an abstract was afterwards made for Al Mamun by Abu Giafar Muhammed ibn Musa al Kwarizmi, who made use of it to prepare his tables, which obtained great renown in the lands of Islam. But when Al Mamun became Caliph, he promoted these noble studies and called in the most learned men in order to examine the *Almagest* and make instruments for new observations.

Arabs and Greeks

The account of which the above is an abstract shows us clearly the origin of the study of astronomy and mathematics under the Abbasid Caliphs. But though the first impulse came from India the further development of Arabian science was to a considerable extent founded on that of Greece and Alexandria. It was through the court physicians from the flourishing medical school kept up by Nestorian Christians of Khusistan that a knowledge of Greek Philosophy and science was first spread among the subjects of the Caliphs; and by degrees the works of Aristotle, Archimedes, Euclid, Apollonius, Ptolemy, and other mathematicians were translated into Arabic. Fresh translations of Ptolemy were made from time to time in the various kingdoms into which the vast empire of the Caliph was soon split up,¹ and a thorough knowledge of Ptolemaic astronomy was thus spread from the Indus to the Ebro. There were several special inducements for Muhamedans to pay attention to astronomy, such as the necessity of determining the direction in which the

1. The earliest is probably that of Al Haggag ben Jusuf ben Matar early in the ninth century. See Suter, *Die Mathematiker und Astronomen der Araber und ihre Werke*, Leipzig, 1900 (p. 9), which valuable bibliographical summary has been followed by J. L. E. Dreyer as regards names and dates (J. L. E. Dreyer's *A History of Astronomy*, 1953; we have reproduced this account from his chapter XI.)

faithful had to turn during prayers, also the importance of the lunar motions for the calendar, and the respect in which judicial astrology was held all over the East. The Caliph Al Mamun, son of Harun Al Rashid (813-833) is the first great patron of science, although the Omayyad Caliphs had much earlier an observatory near Damascus, and the Jew Mashallah (who died about 815) had already before the reign of Al Mamun won a name as an observer and astrologer. But the Damascus observatory became quite eclipsed by that erected at Baghdad in 829 where continuous observations were made and tables of the planetary motions constructed while an important attempt was made to determine the size of the Earth. Among the astronomers of Al Mamun and his successors one of the greatest was Ahmed ben Muhammed Al Fargani (afterwards known in the West as Alfraganus), whose *Elements of Astronomy* were translated into Latin in the twelfth century and contributed greatly to the revival of science in Europe.¹ Tabit ben Korra (826-901) was a most prolific writer and translator, but is chiefly known in the history of astronomy as a supporter of the erroneous idea of the oscillatory motion of the equinoxes. A younger contemporary of his, Muhammed Al Battani (died 929), was the most renowned of all the Arabian astronomers and became known in the West in the twelfth century (under the name of Albategnius) by the translation of the introduction to his tables.² Already in his time the power of the Caliphs had commenced to decline, and they soon lost all temporal power. The study of astronomy was, however, not influenced by this loss of patronage, as the Persian family of the Buyids, who in 946 obtained possession of the post of Amir-al-Omara (corresponding to the Frankish Major Domus) took over the rôle of patrons of science, so long and so honourably carried on by the Abbasid Caliphs. Sharaf al Daula built in 988 a new observatory in the garden of his palace, and among the astronomers who worked there was Muhammed Abu 'I Wefa al Buzjani (959-998), who wrote an *Almagest* in order to

1. First printed at Ferrara in 1493. See the edition of Golius, Amsterdam, 1669.
2. Translated by Plato of Tivoli. First Printed in 1537 after the book of Alfraganus. Dreyer has used the edition of Bologna, 1645, and a new edition which is now being published by C. A. Nallino, of which the Arabic and a Latin translation of the text have already appeared (*Pubbl. d. R. Osservatorio di Brera in Milano*, No. 40, 1899-1903).

make the contents of Ptolemy's work accessible to the less learned. In the nineteenth century this book gave rise to a long controversy, which we shall presently consider somewhat in detail.

Western Countries under Islam

In the eleventh and twelfth centuries we do not find any names of conspicuous astronomers in Muhammedani Asia. But the western countries under Islam had in the meantime become ready to do their share of the work of keeping the mathematical sciences alive. In the Fatimite kingdom of Egypt Ali ben Abi Said Abderrahman ben Ahmed ben Jūnis, generally called Ibn Jūnis (died 1009), was distinguished both as an astronomer and a poet. At Cairo a liberally equipped observatory enabled him to verify the planetary theories which had once been developed in the neighbouring Alexandria, and in token of his gratitude to the reigning sovereign, Al Hakim, he named his work the *Hakemite Tables*.¹ We have to pass to the farthest west to find the next astronomer of mark in the person of Ibrahim Abu Ishak, known as Al Zarkali (in Europe afterwards called *Arzachel*). He was a native of Cordova, lived about 1029-1087, and edited planetary tables called the *Toledo Tables*.² In the following century we find two celebrated astronomers of Seville, Gabir ben Aflah, known as Geber (died 1145, often mistaken for the great alchemist, Gabir ben Haijan, in the eighth century),³ and Nur ed-din al Betrūgi (*Alpetragius*), both of whom raised objections to the planetary theories of Ptolemy, though they failed to produce anything better of their own. Spanish astronomy continued to flourish for a while, although the power of the Arabs in the Peninsula was rapidly declining, and it produced in the thirteenth century a very remarkable man, who, although a Christian king, must be included in this account of Arabian astronomy,

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1. Caussin has published an extract in vol. vii of the *Notices et Extraits des manuscrits* (*Le livre de la grande table Hakemite*). Other Chapters, translated by the elder Sedillot but never published, are reviewed by Delambre, *Hist. de l'astr. du Moyen Age*, p. 95 sqq.
 2. Never published. Delambre, l. c. p. 176, and Steinschneider, *Etudes sur Zarkali*, *Bullettino Boncompagni* T. xx, p. 1.
 3. The word algebra has also sometimes erroneously been connected with his name.

as he owed all he knew about the science to the example and the teaching of Muhammedans and Jews. King Alfonso X, of Castille named el Sabio (1252-1284), followed the example of the Caliphs and called astronomers to his court to assist in the preparation of the renowned Alfonsine Tables.

With Alfonso the study of astronomy disappeared from Spain, but not before it had been revived in the East. In 1258 the still existing but shadowy Caliphate of Baghdad was swept away by the Mongol conqueror Hulagu Khan, grandson of Genghis Khan; but already in the following year this great warrior listened to the advice of his new vazier, Nasir ed-din al Tusi (born at Tus in Khorasan in 1201, died in 1274), and founded a great and magnificent observatory at Merāgha, in the north-west of Persia. In this observatory, which was furnished with a large number of instruments, partly of novel construction, Nasir ed-din and his assistants observed the planets diligently and produced after twelve years labour, the "Ilokhanic Tables." Among the astronomers of Merāgha seems to have been Juhanna Abu 'l Faraj, called Bar Hebrāyā, or the son of a Jew. He was a Christian, born in 1226 and from 1264, till his death in 1286 Maphrian or Primate of the Eastern Jacobites. He left a well-known chronicle and an astronomical work, both written in Syriac, as well as other writings.¹ The observatory at Merāgha had not a long life, and Asiatic astronomy had to wait a century and a half, until the grandson of another terrible conqueror erected another observatory. Ulug Begh, grandson of Tamerlan, drew learned men to Samarkand and built an observatory there about the year 1420, where new planetary tables and a new star catalogue, the first since Ptolemy's, were prepared. Ulug Begh died in 1449, he was the last great Asiatic protector of astronomy; but just as the Eastern countries saw the star of Urania setting, it was rising again for Europe.

In this review of Arabian astronomers we have only mentioned a few, omitting several names of distinction, whose

¹ *Le livre de l' ascension de l' esprit sur la forme du ciel et de la terre. Cours d' Astronomie redigé en 1279 par Gregoire Aboulfarag, dit Bar Hebraeus. Publié par F. Nau, Paris, 1899-1900 (2 parts, Syriac and French). His chronicle is the chief authority for the fable about the burning of the Alexandrian Library by order of the Caliph Omar. For a very thorough refutation of this see Butler, *The Arab Conquest of Egypt*. Oxford, 1902 pp 401-426.*

owners devoted themselves to other branches of astronomy. Though Europe owes a debt of gratitude to the Arabs for keeping alive the flame of science for many centuries and for taking observations, some of which are still of value, it cannot be denied that they left astronomy pretty much as they found it. They determined several important constants anew, but they did not make a single improvement in the planetary theories. It will therefore be sufficient to enumerate the improvements attempted and the opinions held by Arabian astronomers without keeping strictly to the chronological order, although we are here dealing with a period of about six hundred years and men belonging to very different nations, who had little in common except their religion and the language in which they wrote.

Figure of Earth

Turning first to the question of the figure of the Earth, we find a remarkable contrast between Europe and Asia. In the world under Islam there was an entire absence of that hostility to science which distinguished Europe during the first half of the Middle Ages. Though we learn from Kazwini's *Cosmography*¹ that some of the earlier Arabs believed the Earth to be shaped like a shield or a drum, still there is no record of any Arabian having been persecuted for asserting that the Earth is a sphere capable of being inhabited all over. Whether this was in consequence of the warriors of the Caliphs having carried their arms to the centre of France on one side and to the borders of China on the other while their merchants travelled southward to Mazambique and northward to the centre of Asia, is another question : anyhow, the fact of the Earth being a sphere of very small dimensions in comparison to the size of the universe was accepted without opposition by every Arabian scholar, and the very first scientific work undertaken after the rise of astronomy among them was a determination of the size of the Earth. It was carried out by order of the Caliph Al Mamun in the plain of Palmyra. According to the account given by Ibn Junis, the length of a degree was measured by two observers, between Wamia and Tadmor and by two others in another locality, we are not told where. The first measure gave a degree

1. *Zakarija Ben Muhammed Ben Mahmūd El Kazwini's Kosmographie*, deutsch von H. Erbe, Leipzig, 1868, p. 295.

equal to 57, the second one equal to $56\frac{1}{2}$ Arabian miles of 4000 black cubits, and the approximate mean, $56\frac{2}{3}$ miles, was adopted as the final result, the circumference of the Earth being 20,400 miles and the diameter 6500 miles. Another report, by Ahmed ben Abdallah, called Habash, an astronomer under Al Mamun (quoted by Ibn Jūnis), states that a party of observers (no names given) proceeded along the plain of Sinjar until they found a difference in meridian altitudes, measured the same day, equal to one degree, while the distance travelled over was found to be $56\frac{1}{2}$ miles¹. Probably two different determinations were made. If the "black cubit" is the Egyptian and Babylonian cubit of 525 mm.², the mile would be=2100 m. and $56\frac{2}{3}$ miles=119,000 meters, rather a large result.

The doctrine of the spherical earth remained undisputed in the Muhammedan learned world, though the curious error of assuming that the level of the sea was higher on some parts of the Earth than on others appears to have found some adherents among Arabian writers as well as in Europe.³ We may, therefore, at once pass on to the motions of the heavenly bodies. Al Battani determined the longitude of the Sun's apogee and found it=82° or 16° 47' more than Ptolemy had given. As he believed

1. Caussin, *Not. et Extraits*. vii. pp. 94-96; Delambre, *Hist. de l'astr. du Moyen Age*. pp. 78 and 97; Shems ed-din, *Manuel de la cosmographie*, traduit par Mehren, Copenhagen. 1874 p. 6. Suter, p. 209, mentions a third report (from Ibn Challikān's *Biographical Dictionary*), according to which the sons of Musa first measured in the plain of Sinjar and afterwards as a test at Kufa, by order of Al Mamun. The eldest of the sons of Musa died 41 years after Al Mamun, and the names of the observers in the first report are different, so that the third report is not to be relied on. Al Fargani merely gives $56\frac{2}{3}$ miles as the result of Al Mamun. According to Shah Cholgii *Astronomica . . . studie et opera Joh. Gravii*, London, 1652, p. 95, Ala ed-din Al Kūsi (one of the Ulug Begh's astronomers) gives the circumference of the earth=8000 parasangs. As a persian parasang =30 stadia (Hultsch; *Griech u. Rom. Metrologie*, p. 476) this would seem to be the value of Posidonius, 240,000 stadia. Kazwini (p. 298) gives the circumference=6800 parasangs on the authority of Al Berūni.
2. Hultsch p- 390.
3. It deserves to be mentioned that Shems ed-din of Damascus (1256-1327) explains the great Preponderance of dry land in the northern hemisphere by the attraction of the Sun on the water, which is the greatest when the Sun is in perigee, at which time it is nearly at its greatest south declination. That this accumulation of water would not be a permanent one does not occur to him (*Cosmographie*, p. 4).

that Ptolemy's value had been found by himself,¹ and as he adopted $54''$ (or 1° in 66 years) as the annual amount of precession, there remained (assuming that 760 years had passed since the time of Ptolemy) an outstanding error of $79'' - 54'' = 25''$ per annum. In reality the annual motion of the solar apsidal is $11\frac{1}{2}''$; still we may say that the discovery of this motion is due to Al Battani, though he did not announce it as such; in fact he merely gives his own value as an improvement on that of Ptolemy. Even Ibn Junis (who found $86^\circ 10'$) did not suspect that the apogee was steadily moving but merely says that it must be corrected for precession (1° in 70 years), and remarks that the longitude of the apogee is very difficult to determine accurately.² On the other hand, Al Zarkali found a smaller value, $77^\circ 50'$ and as he also found a smaller value of the eccentricity he thought it necessary to let the centre of the Sun's eccentric orbit describe a smaller circle, after the example set by Ptolemy in the case of Mercury.³ The inclination of the ecliptic which the Greeks had found— $23^\circ 51' 20''$ was by the astronomers of Al Mamun found— $23^\circ 33'$ (in 830), by Al Battani (in 879), and by Ibn Junis $23^\circ 35''$. When Al Zarkali found $23^\circ 33'$, he, and afterwards Abu 'l Hassan Ali of Morocco, concluded that the obliquity oscillated between $23^\circ 53'$ and $23^\circ 33'$, an idea to which the prevailing belief in the "trepidation" of the equinoxes lent countenance.⁵

Moon and its orbit

If we now turn to the Moon, we do not find that the Arabs made any advance on Ptolemy. Several of them noticed that the inclination of the lunar orbit was not exactly 5° , as stated by Hipparchus. Thus, Abu 'l Hassan Ali ben Amagiur early in the tenth century says that he had often measured the greatest latitude of the Moon and found results greater than that

1. *Scient. Stell.* Cap. xxviii. Bologna, 1645, p. 72; Nallino. p. 44. At the end of Cap. xlv. he says the apogees of the Sun and Venus are both in $82^\circ 14'$, and Ibn Junis also gives $82^\circ 14'$ as the value found by Al Battani (Caussin, p. 154).
2. Caussin, pp. 232 and 238. Abu'l Faraj gives $89^\circ 28'$ for the year 1279 (p. 22).
3. Sedillot, *Prolegomenes aux tables astron. d'Olough Beg* (1847), pp. lxxx-lxxxii. Riccioli, *Almag. Novum*, I. p. 157.
4. Caussin. p. 56. For A.D. 900 Newcomb gives $23^\circ 34' 54''$, with a diminution of $46''$ per century, so that the Arabian astronomers erred less than $1'$.
5. Aboul Hassan Ali, *Traite des Instruments astron. des Arabes*. T.I.p. 175; Sedillot, *Memoire sur les instr. astr. des Arabes*, p. 32.

of Hipparchus, but varying considerably and irregularly. Ibn Jūnīs, who quotes this, adds that he has himself found $5^{\circ} 3'$ or $5^{\circ} 8'$, while other observers are said to have found from $4^{\circ} 58'$ to $4^{\circ} 45'$.¹ Want of perseverance and of accurate instruments caused them to miss a remarkable discovery, that of the variation of the lunar inclination.

Abu 'l Wefa and his *Almagest*

But an even more remarkable discovery has been claimed for an Arabian astronomer. In 1836 the younger Sedillot announced that he had found the third inequality, the variation, distinctly announced in Abu 'l Wefa's *Almagest*. A fierce controversy raged for a number of years as to the reality of this discovery, Sedillot alone defending his hero with desperate energy and refusing to listen to any arguments, while Biot, Libri and others as strenuously maintained that Abu 'l Wefa simply spoke of the second part of the evection, the *prosneusis* of Ptolemy. The fight had died out when, in 1892, Chasles suddenly took up the cudgels for Sedillot and pointed out what seemed to him to be some contradictions in Ptolemy's statement.² Nobody answered this until Bertrand did so in 1871; he called attention to several inaccuracies in the text of Abu 'l Wefa as we possess it now, and also showed that Abu 'l Wefa did not add his "mohazat" to the *prosneusis*, the latter not being included in his "second anomaly."³ It is unnecessary to enter into a more detailed account of the controversy; but to show that any weapon was considered good enough with which to defend Abu 'l Wefa, it may be mentioned that Sedillot and Chasles tried to prove that Tycho Brahe must have copied his discovery from Abu 'l Wefa, because he calls it *hypothesis redintegrata*. Tycho used this same phrase in speaking of his own planetary system, which he most emphatically claimed as

1. Sedillot, *Prolegomenes*, p. xxxviii. *Matériaux pour servir à l'hist. des sciences chez les Grecs et les Orientaux*, T. I. p. 283. The sons of Musā ben Sakir (about 850) seem to have been the first to find a value differing from that of the ancients. Abraham ben Chiya, a Jewish writer who lived about A. D. 1100 says that Ptolemy found 5° , but that according to the opinion of the Ishmaelites it is $4\frac{1}{2}^{\circ}$ (*Sphaera mundi*, Basle, 1546 p. 102).
2. *Lettre à M. Sedillot sur la question de la variation lunaire*, Paris, 1862, 15 pp. 4° and *Comptes Rendus*, vol. 54, p. 1002.
3. *Comptes Rendus*, vol. 73, pp. 581, 756, 889; *Journal des Savants*, 11 Oct. 1871.

an original discovery, and which he vigorously defended against other claimants. In future it will be hopeless for anybody to claim the discovery for Abu 'l Wefä as the matter has now been thoroughly sifted, both by mathematicians and orientalisks.

The *Almagest* of Abu 'l Wefä has never been published in full, but there are three translations of the chapters in question,¹ which only differ in some trivial points. In no part of the book does he make any advance on Ptolemy or claim to have made any new discovery, and in speaking of three inequalities he merely does what the other Arabian astronomers do.² He begins by describing the first (equation of the centre) and the second (evection) and states when they reach their maxima. He then says that we have found³ a third inequality, which takes place when the centre of the epicycle is between the apogee and the perigee of the eccentric, and which reaches its maximum when the Moon is about a *tathlith* or a *tasdis* from the Sun, while it is insensible in syzygy and quadrature. The maximum is $\frac{3}{4}^\circ$. He explains that this is caused by a deviation of the line or apsides of the epicycle, and he describes quite correctly the construction adopted by Ptolemy (whose name he does not mention), letting the line of apsides be directed, not to the Earth but to another point on the line of apsides of the eccentric. It is difficult for an unbiased reader to understand how anyone could fail to see that Abu 'l Wefä is simply copying Ptolemy. Sedillot maintained that the words *tathlith* and *tasdis* mean the octants (where the variation reaches its maximum); but every other orientalist who has expressed an opinion, states that by their roots the words correspond to the numbers 6 and 3, in other words, to elongations 60° and 120° from the Sun. This is in accordance with

1. By Reinaud, Munk, and de Slane (for Biot) in the *Journal des Savants*, March, 1845 (14 pp. the whole section on the Moon) ; by Sedillot, *Matériaux*, i. pp. 45-49 ; and by Carra de Vaux, "L' almageste d' Abu 'l Wefä Albüzdjani," *Journal asiatique*, 8^e Serie, T. xix. (1892), pp. 408-471 (translation on pp. 443-44). Most of the chapters on the planets are lost.
2. The unknown author of a short resume of astronomy (in the *Bibl. Nationale*) even calls the inequality of prosneusis the first equation (Carra de Vaux, l.c. p. 460). This is not unreasonable, since the equation of the centre must be taken from the lunar tables, using as argument not the mean anomaly but the latter corrected for the effect of the prosneusis.
3. He uses exactly the same expression when speaking of the first and second inequalities.

facts, as Biot has shown from the Ptolemy's numerical data that the deviation of the line of apsides reaches its maximum value of $\pm 13^{\circ} 8' .9$ in elongations $90^{\circ} \mp 32^{\circ} 57' .5$.¹ But it must be acknowledged that the words in question are also used very vaguely, e. g. by Abu 'I Wefa himself, who says that the velocity of the superior planets after emerging from the Sun's rays diminishes gradually till their distance from the Sun is about a *tathlith*, when they become stationary. It looks almost as if these words might be used to denote any elongation outside syzygy and quadrature.²

If Abu 'I Wefa had made a new discovery, we should have expected later Arabian astronomers to have alluded to it. But not one of them gives anything but interpretations of the lunar theory of Ptolemy, and in expressions very similar to those employed by Abu 'I Wefa. Attention was at once called to this fact, and Isaac Israeli of Toledo (about 1310) and Geber of Seville were quoted as examples,³ though it would, of course, have been quite possible for these two writers to have remained ignorant of whatever progress astronomy might have made in the school of Baghdad. But this objection does not apply to Nasir ed-din al Tusi, in whose review of the *Almagest* and *Memorial of Astronomy* the inequalities known to Ptolemy and no others, are described and credited to Ptolemy⁴; not to Mahamud al Jagmini (about 1300), who wrote a compendium (*mulachchas*)

1. *Journal des Savants*, 1843, p. 701 ("Sur un traite arabe relatif a l'astronomie," Reprint, p. 47). This deviation does not represent the amount of the correction to the Moon's place as seen from the Earth, so that there is not any contradiction in Ptolemy's account.
2. Carra de Vaux. l. c. p. 466. The Arabs had no word for "octants." Nasir ed-din on one occasion wants to mention them, and has to call them "the points midway between syzygy and quadrature."
3. Isaac Israeli repeatedly speaks of these inequalities discovered by Ptolemy, two of which are not found at conjunction and opposition. *Liber Jesod, Olam seu Fundamentum Mundi auctore R. Isaac Israeli Hispano*, section III. ch. 8 and sect. v. ch. 16, Part I. p. xxiv Part II. p. xxxi (Berlin, 1848 and 1846; this publication is not mentioned by Carra de Vaux).
4. C. de Vaux, "Les spheres celestes selon Nasir Eddin Attusi", Appendix to P. Tanhery's *Recherches sur l'astr. anc.* p. 342, and *Journ. asiat.* 1892, p. 459: "The third anomaly is that of the prosneusis; it is called the equation of the proper motion" (i.e. of the motion on the epicycle).

of astronomy.¹ Nor can any objection be raised to Abu'l Faraj (Bar Hebraeus), and it would be impossible to explain more clearly than he does the effect of the prosneusis. He says: "The third inequality is the angle formed at the centre of the epicycle by two lines which are drawn, one from the centre of the universe and the other from the point called the prosneusis, at the end of which is the apogee of the epicycle, at which commences the proper motion, and which is called the mean apogee. The apogee which is at the end of the line drawn from the centre of the universe is called the apparent one. The point prosneusis is on the side of the perigee of the eccentric, 10 parts 17 minutes from the centre of the world² which is itself at the same distance from the centre of eccentric. The maximum value of this angle is 13 parts 9 minutes when the Moon is a crescent or $\frac{3}{4}$ gibbous, that is, near the hexagon or trigon with the Sun. In fact, when the epicycle is four or eight signs distant from the apogee of the eccentric, the Sun is itself two or four signs distant from [the centre of the epicycle] because it is half way between this centre and the apogee. In the tables, this inequality of the two apogees is called the first angle and is included in the motion of the centre."³ While this describes the construction of Ptolemy as clearly as possible, at the same time the agreement of the account with that of Abu'l Wefa is perfect. Abu'l Faraj even (like Nasir ed-din) describes as a fourth inequality in longitude that caused by the motion along an orbit inclined to the ecliptic, so that he would not have neglected to describe the variation, if it had been found by an astronomer of Baghdad. We may add that the Jewish writer Abraham ben Chija (A. D. 1100), in his *Sphaera Mundi*, also describes the "aberration" of the apside of the epicycle, chiefly "in sexta et tertia parte mensis."⁴

1. Translated by Rudloff and Hochheim, *Zeitschrift der Deutschen Morgenland Ges.* XLVII pp. 213—275. He describes (p. 249) how the line of apsides is directed to a point called "the corresponding point," and gives its position correctly. The inequality he calls the deviation.
2. Nasir ed-din gives 10° 9'.
3. *Le livre de l' ascension*, & c. T. II. PP. 29-30. Two codices add after the word prosneusis: "This is the point mohazat."
4. *Sphaera Mundi* (1546, ed. Schreckentuchs), p. 75. Munster's commentary to the Hebrew text (p. 116) has "cum centrum est in sextili aut trino aspectu [id est, quando abest a sole duobus signis aut quatuor]"; the words in brackets are not in the Hebrew original. The words "sixth" and "third" are unmistakable (shithith and shelishith). Apparently no one has hitherto thought of consulting Abraham ben Chija.

Abu 'l Wefa and Ptolemy

Therefore, Abu 'l Wefa did not know a single thing about the motion of the Moon which he had not borrowed from Ptolemy. But the prosneusis of Ptolemy is not the variation discovered by Tycho Brahe. The latter depends solely on the elongation of the Moon from the Sun, as it is $= +39' .5 \sin 2\varepsilon$, while it is beyond the power of mortal man to express the effect of the prosneusis without the anomaly. Ptolemy's expression for all the inequalities in longitude assumed by him, when developed analytically, found to contain, in addition to terms representing the equation of the centre and the evection, the latter being

$$+1^{\circ}19'.5 \sin (2\varepsilon - m),$$

a very considerable term

$$+17.8 \sin 2\varepsilon [\cos (2\varepsilon + m) + 2 \cos (2\varepsilon - m)],$$

where ε is the elongation and m the mean anomaly.¹

Obviously this term has nothing in common with the variation, except that it disappears in the syzygies and quadratures. Tycho Brahe did not hang his new term on to the unaltered lunar theory of Ptolemy, and by doing that we should in fact only spoil the latter and make its maximum error rise to more than a degree.² Owing to the insufficiency of the observations at his disposal, Ptolemy could only perceive that there was some outstanding inequality after allowing for the evection, only appearing outside the syzygies and quadratures, but he was neither able to find the law which governed the phenomenon, nor was he aware what a large quantity it represented; he could only tinker up his constructions a little, and in this he was most faithfully followed by the Arabs, who added nothing to what he had done and left it to the reviver of practical astronomy to discover the third lunar inequality.

Al Fargani and others on Planets

Passing to the five planets, we find that, generally speaking, very few attempts were made to improve the work of Ptolemy. But the Arabs were not content to consider the Ptolemaic system

P. Tannery, *Recherches*, p. 213. Another expansion of Ptolemy's lunar inequalities in a series was given by Biot, *Journal des Savants*, 1843, p. 703 (Reprint, p. 49).

P. Kempf, *Untersuchungen über die Ptolemaische Theorie der Mondbewegung*, Berlin, 1878 (Inaug. Diss.), p. 37.

merely as a geometrical aid to computation; they required a real and physically true system of the world, and had therefore to assume solid crystal spheres after the manner of Aristotle. Above the Moon is the Alacir, the fifth essence, which is devoid of lightness and heaviness, and is not Perceptible to the human senses; of this substance the spheres and planets are formed.¹ Already in the book of Al Fargani we find the principle adopted which we have seen dates from the fifth century (Proklus) and which became universally accepted in the Middle Ages, that the greatest distance of a planet is equal to the smallest of the planet immediately above it, so that there are no empty spaces between the spheres.² The semidiameter of the Earth is by Al Fargani given as 3250 miles, which corresponds very nearly to Al Mamun's $56\frac{2}{3}$ miles to a degree, if we put $\pi = \frac{22}{7}$. Starting from Ptolemy's distances of

Greatest Distance of	Al Fargani	Al Battani	Abu 'l Faraj ³
Moon	$64\frac{1}{2}$	$64\frac{1}{2}$	$64\frac{1}{2}$
Mercury	167	166	174
Venus	1,120	1,071	1,160
Sun	1,220	1,146 ⁴	1,260
Mars	8,876	8,022	8,820
Jupiter	14,405	12,924 ⁵	14,259
Saturn	20,110	18,094	19,963

the Moon and the Sun, it was easy to express the other distances in semidiameters of the Earth, the ratios between the greatest and

1. Al Battani, cap. 50 (p. 195).
2. Al Fargani, cap. 21 (ed. Golius, p. 80). Much later, Maurolycus in his *Cosmographia* (Venice, 1543, f. 20a) proves that Mercury and Venus must be below the Sun, by pointing out that there would otherwise be a large vacant space between the Sun and the Moon.
3. pp. 189-191.
4. So in Nallino's ed. (Milan, 1903 p. 121) the ed. of 1645 has 1176.
5. The ed. of 1645 has 12, 420; obviously an error, as the ratio of greatest to smallest distance is given as 37:23 for Saturn 7:5 (misprinted 7:2), or "quantitas unius et duarum quintarum ad unum" (p. 199). Nallino's ed (Milan 1903) has 12,924. Abraham ben Chija has 12,400.

smallest distances being in substantial agreement with the theory of Ptolemy. Al Battani also gives a similar set of figures, though with some slight differences. He does not mention peculiar treatment given by Ptolemy to the theory of Mercury. The above table gives the distance expressed in semidiameters of the Earth.

Al Kusgi and diameters of planets

Al Kūsgi, one of the astronomers of Ulug Begh, gives a list of the semidiameters of the "concavities" of the planetary spheres (i.e. the smallest distances of the spheres) expressed in parasangs, the diameter of the Earth being 2,545 parasangs.¹ Expressed in semidiameters of the Earth, the figures turn out somewhat different from those given above, e.g. the smallest distance of the Sun being 1,452 and the greatest of Saturn 26,332, but he does not supply any means of making out how these figures were found.

Before leaving this subject, we shall also give the diameters of the planets according to Al Fargani, as they became known in Europe at an early date and were quoted by Roger Bacon and others.² With trifling variations the same values are given by Al Battani, Abu 'l Faraj, and Abraham ben Chija.

	Apparent Diameter	True Diameter (Earth's=1)
Moon in apogee	$31\frac{2}{3}'$	$1 : 3\frac{1}{2}$
Mercury, mean dist.	$\frac{1}{18}$ of Sun's	$\frac{1}{18}$
Venus " "	$\frac{1}{10}$ " "	$1 : 3\frac{1}{2}$
Sun " "	$31\frac{2}{3}'$	$5\frac{1}{2}$
Mars " "	$\frac{1}{10}$ of Sun's	$1\frac{1}{2}$
Jupiter " "	$\frac{1}{12}$ of Sun's	$4\frac{1}{2} + \frac{1}{12}$
Saturn " "	$\frac{1}{18}$ " "	$4\frac{1}{2}$

Al Kazwini, Abu'l Faraj and

Al-Jagmini on Excentric Spheres of the Sun

The system of the spheres is set forth in greatest detail in three treatises of later date, the cosmography of Zakarija ben Muhammed ben Mahmud al Kazwini (about 1275), the astronomy

1. *Astronomica Shah Chelgii*, pp. 95-97.

2. There are some slight differences between the figures given in the various editions (J.L.E. Dreyer has compared those of 1493, 1546, and 1669), but those given above agree with the cubic contents according to Al Fargani. The figures of Kazwini seem to have been greatly corrupted.

of Abu 'l Faraj, written in 1279, and that of Mahmud ibn Muhammed ibn Omar al Jagmini, whose date and nationality are equally uncertain, but who probably wrote in the thirteenth or fourteenth century. We find in these text-books an elaborate system of spheres designed to account for every particular of planetary motion, in perfect agreement with each other as to the general arrangement of the spheres, and offering nothing new as to lunar or planetary theory. The accompanying figures (taken from Jagmini) will illustrate the ideas better than a lengthy description.¹ The Sun is a solid sperical body, fitting between two excentric spherical surfaces, which touch two other surfaces, in the

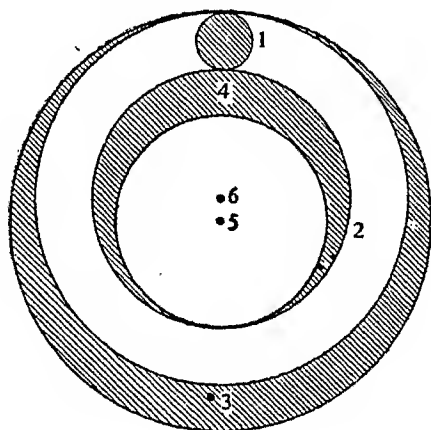


Fig. 1.—Planetary motions and system of spheres.

1. The Sun. 2. Excentric sphere. 3. The surrounding spheres. 4. The complement of the surrounding sphere.
5. Centre of the world. 6. Centre of the excentric sphere.

common centre of which the Earth is situated, and which between them enclose a space (or intersphere, as Abu 'l Faraj calls it), named by Jagmini al-mumattal, or the equably turning sphere, which has the same motion from west to east as the fixed stars, i.e. precession. The spheres of the three outer planets and Venus are arranged on the same plan, except that the place of the body of the Sun is taken by the epicycle-sphere of each planet, to the inner surface of which the planet (a solid spherical body) is attached or (as Abu 'l Faraj says²) "fixed like a pearl on a ring, touching the

1. Al Kusgi gives very similar diagrams of the spheres of the Saturn, Mercury, and the Moon.
 2. Precession is supposed to be included in this, "the first motion." The second
- (Continued on next page)

excentric sphere. The figure shows the excentric sphere enclosed in a sphere, *al-mūdir* or the turning one, which allows the upper apsis or apogee of the excentric or deferent sphere (3 in the figure) to move right round the outer surface of the *mūdir*. The inner surface of the *mumattal* sphere immediately surrounds the *gauzahar* sphere of the Moon.

It was a necessary consequence of the large solar parallax of 3' accepted by Ptolemy, that Mercury and Venus must be very near the Earth, since they are assumed to be nearer than the Sun. Thus Abraham ben Chija says that the shadow of the Earth extends beyond the orbit of Mercury but does not reach that of Venus.¹ Ptolemy never mentions the parallaxes of Mercury and Venus, as to which nothing was known, though they ought, of course, to be greater than 3'. But on the assumption that the smallest distance of Mercury is equal to the distance of the Moon at apogee, the parallax of Mercury ought to rise to 54', which must have been felt to be too large a quantity, though it does not seem to have struck Al Battani as anything surprising, perhaps because Mercury cannot be seen when in inferior conjunction. It may have been this necessarily large parallax of Mercury, which induced Ibn Jūnīs (without any explanation) to reduce the solar parallax from 3 to 2', or rather to 1' 57".² Geber³ blames Ptolemy for having said that the parallaxes of the planets are insensible, and remarks that he ought, therefore, logically to have placed Venus and Mercury above the Sun. He takes great pains to show that Venus may be exactly on the line joining the Sun and the Earth. Indeed, Geber neglects no opportunity of criticising Ptolemy's methods of finding the elements of the orbits,⁴ and he is generally very unjust to him but he does not venture to

1. *Sphaera mundi*, ed. Osw. Schrekenfuchs, Basle, 1546 pp. 84, 86.

2. Unpublished chapters of Ibn Jūnīs, reviewed by Delambre, *Hist. de l'astr. du Moyen Age*, p. 101.

3. *Instrumentum primi mobilis a P. Apiano. Accedunt ijs Gebri filii Affla Hispalensis. . . libri IX. de astronomia*. Norimbergæ, 1534, fol. (Introd. p. 3 and lib. VII, p. 104).

4. See the long indictment on pp. 2-3 of his introduction. He blames Ptolemy among other things for assuming that the centre of the deferent is half-way between the centres of the zodiac and of the equant, while he himself deduces this from the movements.

substitute any other system and does not object to the general principles of the Ptolemaic system,¹

Three great names :

Ibn Badja, Ibn Tofeil (Abubacer) and Abu Welid (Averroes)

Geber's attempts to pick holes in the work of Ptolemy were, perhaps, not unconnected with the rapid rise of Aristotelean philosophy in Spain in the twelfth century, which, though not destined to last long, nevertheless exercised a considerable influence on the spread of knowledge of Aristotle in the Christian world, while it cast a halo round the Caliphate of Cordova, which at that time, under the enlightened rule of the Almohades, seemed to have reestablished the glory of the best days of the Moslem world. Three names are specially associated with this movement :

- (i) Abu Bekr Muhammed Ibn Jahya al Sayeg, called Ibn Badja (of Saragossa, died 1139), known as Avempace among the Scholastics ;
- (ii) his pupil Muhammed ben Abdelmelik Ibn Tofeil (of Granada, died 1185-1186), called Abubacer by the Scholastics ;
- (iii) and finally the greatest philosopher of Islam, Ibn Rosd Abu Welid, known as Averroes (1126-1198).

In studying Aristotle they laid special stress on his scientific works, and did not, like their Christian successors, think of little but dialectics. The acceptance of the system of homocentric spheres or some modification of it must, therefore, have seemed a necessity to the Arabian philosophers and this, of course, led them to reject the theory of epicycles. The little we know of the opinions of Ibn Badja on this subject is found in the famous work *The Guide of the Perplexed* of the great Jewish scholar Moses ben Maimun of Cordova, better known as Maimonides, who tells us that he had his information from a pupil of Ibn Badja. Like Geber (with whose son he had been familiar), Maimonides doubted that Mercury and Venus were nearer than

1. Copernicus possessed a copy of Geber's book; which is now in the University library at Upsala. On the title page, after the author's name, he has written : "Egregii, Calumiatoris Ptolemaei," while a number of marginal notes show that he has read the book carefully. Curtze, *Mittheilungen des Copernicus Vereins*, I, p. 37.

the Sun, though he would not venture to say how they actually moved.¹ But what is more important, he declared the motion of a planet on an epicycle to be contrary to physical principles, because there are only three motions possible in this world : around its centre, or towards it, or away from it; while he also maintained that according to Aristotle circular motion can only take place round a real, central body.² Though Aristotle in reality did not object to epicyclic motion with a mathematical point as centre, for the simple reason that it had not been proposed when he wrote, while, as we have seen, his moving principle had nothing to do with the centre of motion, it is easy to see that Ibn Badja's real difficulty was the same which afterwards produced so many obstacles to the advance of science in Europe : whatever could not be found in Aristotle's book must be unworthy of notice. According to Maimonides (who, however, makes the reservation that he had not heard it from disciples), Ibn Badja constructed a system of his own, in which he only admitted excentric circles but no epicycles. We are not given any particulars as to this system but there can hardly be any doubt that its author confined himself to generalities and did not attempt to represent phenomena like the lunar inequalities by it. Maimonides remarks that there is nothing gained by Ibn Badja's reform, since the excentric hypothesis is as objectionable as the epicyclic one, as it also supposes motion round an imaginary point outside the centre of the Earth. The centre of the 'excentric, on which the Sun is supposed to move, is outside the convexity of the lunar sphere and inside the concavity of that of Saturn's excentric is between the spheres of Mars and Jupiter. He adds that the revolution of a number of concentric spheres around a common axis is conceivable, but not the revolution round different axes inclined to each other, as the spheres would disturb each other unless there are other spherical bodies between them. This attempt to revive and modify the system of (movable ?) excentrics did, therefore, not mend matters.³

1. *Rabbi Moses Majemonidis Liber Doctor Perplexorum*. Basileæ, 1629, Pars II, cap. IX.
2. *Ibid.*, Pars II, cap. XXIV.
3. Maimonides also remarks (in the same chapter) that the supposed inclinations of Mercury and Venus in the Ptolemaic system are difficult or impossible to comprehend or imagine as really existing. Therefore, if what

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Ibn Tofeil

Ibn Tofeil, the second of the three Moslem philosophers of Spain, vizier and physician at the court of Jusuf ben Abd el Mumin of Morocco, seems to have walked in the footsteps of his master; but the only extant work of his, a kind of religious mystic romance about the emancipation of a soul from the trammels of this material world, does not give any clue to his ideas as to the planetary system. But Averroes, who also objected to the excentrics and epicycles says in his commentary to Aristotle's *Metaphysics* that Ibn Tofeil possessed on this subject excellent theories ², and Ibn Tofeil's pupil, the astronomer Al Betrugi, in the introduction to his theory of the planets, says of him: "You know that the illustrious judge Abu Bekar Ibn Tofeil told us that he had found an astronomical system and principles of the various movements different from those laid down by Ptolemy and without admitting either excentrics or epicycles, and with this system all the motions are represented without error." Ibn Tofeil was therefore probably the real author of the fairly elaborate system, which his pupil worked out and handed down to us in a work on the planets, which was translated into Hebrew in the following century and from that again into Latin, and published in 1531 ³.

The object of this system was to explain the constitution of the universe as it really is, and not merely to represent the motions of the planets geometrically, so as to be able to foretell their places in the heavens at any time; and the author (be he Ibn Tofeil or Al Betrugi alias Alpetragius) specially disclaims any intention of testing the theory by comparing it with observations

(Continued from previous page)

Aristotle says is true, there is neither epicycle nor excentric, and everything turns round the centre of the Earth.

2. Munk; *Mélanges de philosophie juive et arabe*. Paris, 1859, p. 412.
3. Alpetragii Arabi Planetarum theorica phisicis rationibus probata, nuperrime latinis litteris mandata a Calo Calonymos, Hebreo Neapolitano, Venice 1531, 28 ff. folio (published with Sacrobosco's *Sphaera*). A translation by the famous Michael Scot has never been printed, but is still extant in Paris (Munk, *Mélanges*, p. 519). The principle of the system is described by Isaac Israeli, who, however, does not mention the author's name (*Liber Jesod Olam*, II, 9, Part I, p. XI).

or of accounting for minor details of the motions.¹ The leading idea is that of the homocentric spheres, each star being attached to a sphere, and the motive power is the ninth sphere, the sphere outside that of the fixed stars. The Spanish philosopher ought, therefore, to have been content with the system of Eudoxus or its modification by Aristotle (whom he never mentions by name, but only as "the sage"), but unfortunately he became possessed with the notion that the prime mover must everywhere produce only a motion from east to west, and he had, therefore, to reject the independent motion of the planets from west to east, and revert to the old Ionian idea that the seven planets merely perform the daily revolution with a speed slightly slower than that of the fixed stars. The true speed of the *primum mobile* is a little faster than this; the eighth sphere performs a revolution in a slightly longer period (24 hours), and the effect of the prime mover is gradually weakened more and more, with increasing distance, until we find the sphere of the Moon, being furthest from the prime mover, taking nearly twenty-five hours to complete a revolution. This was the old primitive Ionian idea, but Al Betrugi (or his teacher) saw that this was not sufficient, as not only is the pole of the ecliptic different from that of the equator, which prevents the planets from moving in closed orbits, but the planets do not even keep at the same distance from the pole of the ecliptic but have each their motion in latitude, as well as variable velocity in longitude; and all this had yet to be accounted for. The ninth sphere has but one motion, but the eighth has two, that in longitude (precession) and another which is caused by the pole of the ecliptic describing a small circle round a mean position, thereby producing the supposed oscillation or trepidation of the equinoxes.² Similarly, the pole of each planet describes a small circle round a mean position (i. e. the pole of the ecliptic), thereby producing inequalities in longitude and motion in latitude.³ Whenever the actual orbit-pole of a planet is on the parallel of the mean pole, it is obvious that the planet will perform its daily revolution with its mean velocity, while the velocity is increased or lessened when the actual pole is respectively at its minimum or maximum distance from the pole of the heavens

1. Fol. 8 b.

2. Fol. 9 b.

3. Fol. 14 b.; sq.

(the motion of the pole of the orbit being added to or subtracted from the motion of the planet), so that the epicycle is hereby rendered superfluous. The lengths of the radii of these small circles are not given, except in the case of Saturn, where the radius is $3^{\circ} 3'$,¹ while the mean pole of the moon is 5° (the inclination of the lunar orbit) distant from the pole of the ecliptic,² and the small circle is so exceedingly small as to produce no retrograde motion, which is also the case with the Sun. The periods of the poles of the outer planets are given by the following figures Saturn makes 57 revolutions in 59 years and $1\frac{1}{2} + \frac{1}{4}$ days, in which period the mean pole lags behind 2 revolutions $1\frac{2}{3}^{\circ} + \frac{2}{3}^{\circ}$. Jupiter makes 65 revolutions in 71 years, the mean pole lagging behind 6 revolutions. Mars makes 37 revolutions in 79 years and $3\frac{1}{2} + \frac{1}{4}$ days, the pole lagging behind 42 revolutions and $3\frac{1}{4}^{\circ}$.

In other words, the motion on these small circles are completed in the synodic periods of planets. Similarly, the pole of Venus makes 5 revolutions in the 8 years less $2\frac{1}{4}d + \frac{1}{5}d$, lagging $1\frac{1}{2}$ revolutions in one year; and Mercury 145 revolutions in 46 years and $1\frac{1}{3}d$.⁴ It is curious that Alpetragius alters the order of the planets placing Venus between Mars and the Sun, because the defectus (lagging) of Venus smaller than that of the Sun.⁵ He also says that nobody has given any valid reason for accepting the usually assumed order of the planets, and that Ptolemy is wrong in stating that Mercury and Venus are never exactly in a line with the Sun (a remark already made by Geber); and as they shine by their own light they would not appear as dark spots, if passing between us and the Sun. That they do not receive their light from the Sun is proved, he thinks, by the fact that they never appear crescent-shaped.⁶

There is no need to dwell any longer on this quaint theory

1. Fol. 16 a.

2. Fol. 25 a.

3. Fol. 16 a, 18 a, 19 b.

4. Fol. 21 b, 24 b.

5. "Nam reperimus defectum eius primum minorem defectu orbis solis et maiorem defectu orbis martis, et sequitur juxta radices nostras ut sit inter eos ambos."

6. Fol. 21 a

of spiral motion, as it has been rather improperly called.¹ It represented a retrograde step of exceedingly great magnitude, totally unjustified as the theory could not seriously pretend to be superior to the Ptolemaic system, which had only become so very simple if one was content with representing only the principal phenomena. We are told by the Jewish astronomer Isaac Israeli of Toledo, that the new system made a great sensation, but that it was not sufficiently worked out to be taken seriously, and that the system of Ptolemy, founded on the most rigorous calculations, could not be superseded by it.² Another Jewish author, Levi ben Gerson, in a work written in 1328, entered into a lengthy refutation of the hypotheses of Al Betrugi.³ But the latter certainly represented a general desire on the part of the Spanish Aristoteleans to overcome the physical difficulties in accepting the Ptolemaic system; thus Averroes says that the astronomy of Ptolemy is merely a convenient means of computing, and that he himself in his youth had hoped to prepare a work on the subject.

Nasir ed-din Al Tūsi

While ineffectual attempts were being made in the far west, to devise a new astronomical theory, the astronomers of the east did not remain blind to the desirability of finding a system, in which the planets were not supposed to move unsupported in space in such a wonderfully complicated manner; and in the thirteenth century we find one of the greatest astronomers, Nasir ed-din Al Tūsi, advocating a system of spheres which he supposed to be more acceptable than excentrics and epicycles.⁴ In addition to a review or digest of the *Syntaxis* of Ptolemy he wrote a shorter work entitled *Memorial of Astronomy*, in various

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1. e.g. by Riccioli, *Almag. Nov.* T. I. p. 504, where Kepler's figure of the real motion of Mars in space from 1580 to 1596 (supposing the earth to be at rest) is copied, as if that had anything to do with the "Spirals" of Alpetragius.
 2. He adds that he was not qualified himself to sit in judgment on the proposed system (*Liber Jesod Olam*, II. 9, p. XI.)
 3. Munk, *Melanges* pp. 500 and 521.
 4. "*Less spheres celestes selon Nasir-Eddin Al tūsi. Par M. Carra de Vaux.*" Appendix VI. to Tannery's *Recherches sur l'astr. anc.* pp. 337—360. Includes a translation of the chapter in which the new theory is set forth.

passages of which he shows his dissatisfaction with the Ptolemaic system. In the chapter on the Moon (to which we have already alluded) he counts up the various anomalies, among which he mentions the anomaly of illumination, that is, the spots on the Moon, which he believes to be caused by other bodies moving in the lunar epicycle and unequally exposed to the Moon's light. He then says that we should expect in a simple theory to find the centre of the epicycle in equal times describing equal arcs on the deferent, and the diameter of the epicycle joining the pericentre and the apocentre pointing to the centre of the deferent. But neither of these conditions is fulfilled. In the theories of the planets he makes the same objections, which it must be said are very just, since the introduction of the equant was a very unnatural arrangement. But this is nothing to the artificial machinery designed by Ptolemy to account for the motion in latitude of the five planets, especially of Mercury and Venus. Nasir ed-din describes the marvellously complicated movements of the deferents and epicycles of these planets, and remarks that "these motions require the introduction of a system of guiding spheres, about which the ancients have not said anything". He next proceeds in the following chapter to explain a system of his own which allows us to discard these combinations.

First he proves that if there are two circles in one plane, one touching the other internally and of a diameter equal to half that of the other, and if the greater one rotates, and a point moves along the circumference of the smaller one in the opposite direction with twice the velocity and starting from the point of contact, then that point will move along a diameter of the greater circle.¹ These two circles may now be assumed to be the equators of two spheres, and for the point we may substitute a sphere representing the Moon's epicycle (1 in the figure), Nasir ed-din assumes another sphere (2) surrounding the epicycle and destined to keep the diameter from apogee to perigee in its place always coinciding with the diameter of the sphere (4) "let us give it a suitable thickness, but not too great, so as not to take up too much space." He next assumes two more spheres, one (3) which corresponds to the smaller sphere in the distance of the centre of the deferent in the Ptolemaic system from the

1. Compare Copernicus, *De revolutionibus*, III. 4 (Secular ed. 1873, p. 166).

centre of the Earth; and another sphere (4) with a diameter twice as great. Finally (4) is placed in the interior of a carrying sphere (5) concentric with the world and occupying the concavity of the

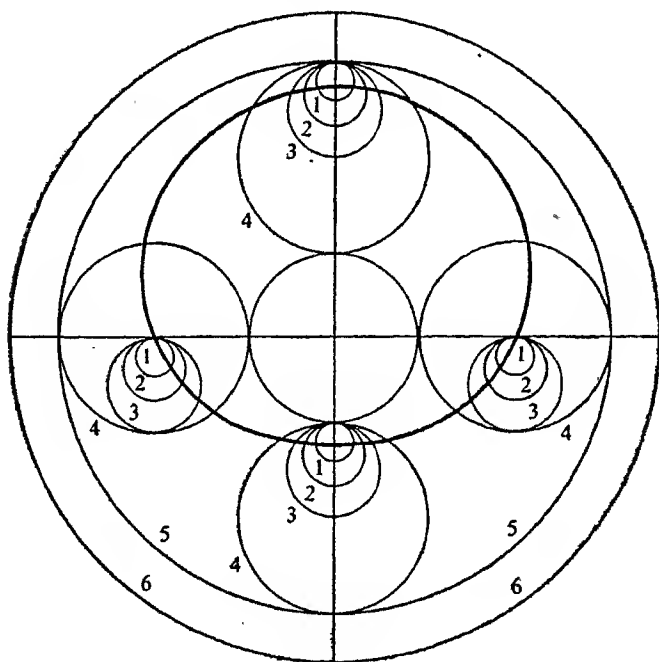


Fig. 3.—Movements of deferents and epicycles of planets.

The thickline is not a circle. All others are circles.

sphere (6), the equator of which is in the plane of the lunar orbit. (2) and (4) and (5) revolve in the same period, that in which the centre of the epicycle performs a revolution; (3) revolves in half that time, while (6) revolves in the opposite direction with the same speed as the apogee of the excentric. The figure now shows how the epicycle moves to and fro along the diameter of (4) and during the revolution of the circle (5) describes a closed curve, about which Nasir ed-din justly says that it is somewhat like a circle but is not really one, for which reason it is not a perfect substitute for the eccentric circle of Ptolemy. He estimates the greatest difference between the lunar places given by the two theories as one-sixth of a degree, half-way between syzygy and quadrature. Except for the action of the guiding sphere (2), it would not be the centre of the epicycle but the point of contact of circles (3) and (4), which describes the curve resembling a circle. The same

method may be adopted for Venus and the three outer planets, and Nasir ed-din promises to explain the new theory of Mercury in an appendix, but this appears to have been lost.

Nasir ed-din also endeavours to improve on the machinery proposed by Ptolemy to illustrate the manner in which the epicycle remains parallel to the plane of the ecliptic. He mentions that the celebrated Ibn al Haitham (afterwards known in the west as Alhazen, author of a well-known book on optics) had written a chapter on this subject, adding to each epicycle two spheres to account for the inclination of the diameter perigee-apogee, and two additional ones for the inferior planets for the diameter at right angles thereto.¹ Nasir ed-din makes use of the same principle which guided him in his demonstration about the motion in longitude, and he shows how in this way we may by means of two spheres make the extremities of the diameter of the epicycle move backwards and forwards along an arc of a sphere.² He claims that this arrangement is superior to that of Ptolemy by not introducing any error in longitude,³ but he acknowledges that he has not been able to get rid of the strong objection to Ptolemy's auxiliary circle, viz. that the irregular motion in longitude with regard to the centre of the deferent necessitates the introduction of a corresponding irregularity in the motion on the auxiliary circle by letting the motion be uniform with regard to an equant. It baffled Nasir ed-din's ingenuity to find an arrangement of spheres which could obviate the necessity of having recourse to this expedient.

All the attempts at rebellion against the Ptolemaic system had thus turned out failures. And they deserved nothing else, since it was impossible to find anything better than what Ptolemy had produced, until it was perceived that where Ptolemy was wrong was not in his mathematical methods, which were perfect, but in the fundamental idea of the Earth being at rest. The time

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1. Ibn al Haitham said that by using discs instead of spheres one might complete the demonstration; but Nasir ed-din objects to the arrangement (about which he gives no details) that a non-spherical system is not in accordance with the principles of astronomy.
 2. It is not quite clear whether this plan is his own or is the same as Ibn al Haitham's.
 3. Due to disturbance of the position of the diameter from perigee to apogee, from which the anomaly is counted.

was apparently not ripe for a radical change with regard to this idea. Though the doctrine of the Earth's motion does not seem to have been mentioned by Arabian writers, we have evidence that the hypothesis of the daily rotation of the Earth was not unknown among them, a natural consequence of their familiarity with the writers of antiquity. One of Nasir ed-din's fellow-workers at the Meragha observatory, Ali Negm ed-din al Katibi, who died in 1277, wrote a book, the *Hikmat al-ain*, on philosophy, in which he combats this opinion, which he attributes to "some philosophers." "I do not," he says, "advance as an argument against it that, if this were the case, a bird flying in the direction of the motion of the Earth would not be able to keep up with it, because the motion of the Earth would be much faster than that of a bird, inasmuch as it returns to its place in a day and a night. Such an argument is not conclusive, because it may be urged that the atmosphere which is close to the Earth partakes of its motion as the ether partakes of the motion of the heavenly sphere. But I reject this theory, because all terrestrial motions take place in a straight line, and therefore we cannot admit that the Earth should move in a circle."¹

What reformation of astronomy could be hoped for, as long as this kind of argument could be used? We cannot see from this remark of Katibi's whether there really were any Arabian philosophers who believed in the rotation of the Earth. It is, however, stated in the *Zohar*, the great Kabbalistic work attributed to Mosheh ben Shemtob of Leon (died 1305), that a certain Rabbi Hamnuna the Elder (otherwise unknown) taught that "the Earth turns like a sphere in a circle and that some people are above and others below."² Though this passage as well as others in the *Zohar* may have been interpolated much later, it would

1. A. Sprenger, "The Copernican System of Astronomy among the Arabs," *Journ. Asiatic Society of Bengal*, Vol. XXV. (1857), p. 189. Katibi's contemporary, Abu 'l Faraj (II. p. 10) deems it necessary to prove that the Earth cannot be in motion, neither rectilinear nor circular, but his arguments (about birds and stones flung upwards) seem merely taken from Ptolemy, lib. I. cap. 6. Kazwini (*Kosmographie*, p. 296) says that among the ancients there were some adherents of Pythagoras who maintained that the Earth continually moves round in a circle; but whether these adherents were Greeks or Arabians cannot be seen from the context.
2. *Sohar*, Amsterdam, 1718, T. III. f. 10a; Gunther, *Studien Z. Gesch. d. math. Geogr.*, p. 113.

after all not be very surprising if some learned Jews had been influenced by the opinion of Herakleides, since it is an established fact that the doctrines of the Kabbalists were intimately connected with the later Greek philosophy. But any how nothing came of this isolated case, and the daily rotation of the heavens continued to be universally accepted as a self-evident fact.

Arabian astronomers and Ptolemaic system—

Arabian astronomers who really wished to follow in detail the celestial motion were therefore obliged to adopt the Ptolemaic system altogether. New planetary tables had long been found to be a necessity, and this important work was at last undertaken by King Alfonso X. of Castille and several Jewish and Christian astronomers working under him at Toledo, who prepared the celebrated Alfonsine Tables, Apparently the King must have had his doubts about the physical truth of the system, judging from his well-known saying that if God had consulted him when creating the world, he would have given Him good advice. The tables were prepared under the direction of the Jew Ishak ben Said, called Hasan, and a physician, Jehuda ben Mose Cohen, and were finished in 1252, the year in which Alfonso ascended the throne of Castille. They continued in great repute for three hundred years as the best planetary tables; they were first printed in 1483, but had been spread all over Europe long before that time in numerous MS copies, many of which are still in existence, Twenty-six codices are counted up in the *Libros del Saber de Astronomia del Rey D. Alfonso X. de Castella*, Madrid, 1863-67 (5 vols. fol.). This compilation, a series of chapters on spherical and theoretical astronomy followed by tables, must have been made up from several codices, as there are numerous repetitions even of very elementary matters. In the third volume the theories of the planets are dealt with, but one looks in vain for any improvement on Ptolemy; on the contrary, the low state of astronomy in the Middle Ages is nowhere better illustrated. In general the elements of the orbits are those of Ptolemy, though sometimes only approximations are given, while different values are given in different chapters, though Ptolemy places the centre of the deferent midway between the centre of the equant and the Earth, the *Libros del Saber* places the centre of the equant (*cercos del alaux*.¹) midway between the Earth and the centre of the deferent

1. *al* is the Arabic article, *aux* (apside) is a corruption of the Arabic *Oudj* (Abu'l Faraj, II. p. 25). The equant is called the *cercos del Y guador*.

(*cerco del levador*¹), as in Ptolemy's theory of Mercury, which the authors would seem to have extended to the planets, omitting the motion of the centre of the deferent on a small circle; this, they have, however, correctly given in the case of Mercury.² There is a very curious figure³ of the deferent of Mercury in the form of an ellipse (the axes being as 6 to 5 nearly), with what looks like the Sun in the centre. This curve has been constructed from a number of small circular arcs,⁴ and it is obviously nothing but the curve described by the centre of the epicycle of Mercury in Ptolemy's theory. For according to the latter the centre of the deferent describes a small circle with radius = $\frac{1}{31}$ of that of the deferent, in direction from east to west, in the same time which the centre of the epicycle takes to pass round the circumference of the deferent from west to east. This makes the centre of the epicycle describe a closed curve resembling an ellipse, the axes of which are in the ratio 11: 10, almost exactly the same as in the Spanish diagram, and there is therefore in the latter no anticipation whatever of Kepler's great discovery, since in the case of the inferior planets it is the epicycle which is the real orbit.⁵ The small sun-like object in the centre of the ellipse represents the centre of Ptolemy's small circle, and it has either been inserted in the manuscript centuries after the essay had been written, or, more likely, it has been caused by a small blot on the place in the parchment where the stationary leg of the draughtsman's compasses had made a small hole. An oval deferent of Mercury occurs in several books published in the sixteenth and seventeenth centuries.⁶

1. Vol. III, pp. 246—253.

2. Vol. III, pp. 253 and 278. In the latter place the radius of the small circle is $\frac{1}{31}$, as in the "*Hypotheses*" of Ptolemy.

3. Vol. III, p. 282.

4. See the lengthy description on pp. 278—280.

5. The editor, Don Manuel Rice y Sinobas, on p. xxxiii, of his preface, even goes so far as to suggest that Kepler may have known of this great discovery of Alfonso's or rather of Arzachel's, as the text attributes the construction to him. This and other similar diagrams were intended to be used instead of planetary tables in the manner afterwards adopted by Apianus.

6. First (about 1460) in Purbach's *Theoricae novae Planetarum* (ed. of Basle, 1573, p. 82): "Ex dictis apparer manifeste, centrum epicycle Mercurij,

Though the somewhat confused collection of essays entitled the *Libros del Saber* would not, if published in the thirteenth century, have advanced astronomical science, it cannot be denied that the Alfonsine Tables were very useful in their day. The actual elements are not given, nor is any thing said about any observations by which somewhat more correct values of the mean motions must have been found.¹

Arabs on motions of fixed stars.

Thus we finish our review of the planetary theories of the Arabs. Now we shall say a few words about their ideas as to the nature and motion of the fixed stars. The exaggerated notion which prevailed before the invention of the telescope with regard to the apparent angular diameters of the stars naturally, led to erroneous estimates of their actual size, founded on the assumption that the sphere of the fixed stars (the eighth sphere) was immediately outside that of Saturn.² The stars of the first magnitude were supposed to have an apparent diameter equal to $\frac{1}{2}$ of that of the Sun, from which it followed that their actual diameters were about $4\frac{3}{4}$ times that of the Earth, or about

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propter motus supradictos non (ut in alijs planetis fit) circumferentiam deferentis circulare, sed potius figuræ, habentis similitudinem cum plana ovali peripheriam describere." Next by Albert of Brudzew in 1432 in his *Commentariolum super theoricis novas*, printed at Milan in 1495 (ed. Cracow, 1900, p. 124), where it is remarked that the centre of the lunar epicycle describes a similar figure. This is also stated by E. Reinhold in his commentary to Purbach, 1542, fol. p. 7 verso (ed. of Paris, 1558, fol. 78,) by Vurstisius in his *Questiones novae in theoricis*, & c., Basle, 1573, p. 233; and in Riccioli's *Almagestum novum* T. I. p. 564. The last three writers (who give a figure) also take the equable angular motion round the centre of the equant into account, which centre lies on the point of the circumference of the small circle nearest the Earth. The curve described by the centre of the epicycle thus becomes egg-shaped, and not like an ellipse.

1. The tables in vol. v. of the *Libros del Saber* are quite different from the Alfonsine Tables, and are apparently only intended for astrological purposes.
2. Al Battani (cap. 50) gives the greatest distance of Saturn=18,094, and the distance of the fixed stars=19,000 semidiameters of the Earth. Al Fargani (p. 82) puts them exactly equal. Al Kusgi gives the diameters in parasangs, of the concavity of the stellar sphere=33,509,180 of the ninth sphere 33,524,309, of its convexity "no one but God knows" (Shah Cholgi, p. 97).

twice that of Mars.¹ As to the nature of the stars, they seem generally to have been assumed self-luminous, being condensed parts of the sphere, though Abraham ben Chija says that the eighth sphere does not shine with a uniform light, but has denser spots, which are illuminated by the Sun and appear to us as the fixed stars.²

To account for the apparent slow motion of the stars paralleled to the ecliptic, from west to east, whereby their longitudes increase while their latitudes remain unaltered, it became necessary to introduce a ninth sphere (*primum mobile*), turning in twenty-four hours and communicating this motion to the eighth sphere, while the latter moved extremely slowly round its own axis forming an angle of $23^{\circ} 35'$ with that of the ninth.³ But the simple phenomenon of precession was by many Arabian astronomers complicated by being assumed variable. It may be mentioned that according to Theon and Proklus it had been assumed by some astronomers apparently before the time of Ptolemy, that the precessional motion of the stars was not progressive, but was confined to an oscillation along an arc of 8° , along which the equinoctial points moved backwards and forwards on the ecliptic, always at the same rate of 1° in 80 years. The absurdity of the sudden change of direction must have become obvious as soon as astronomy began to be cultivated among the Arabs, for we find that one of the earliest astronomers, Tābit ben Korra, substituted a physically less objectionable theory.⁴

1. Al Fargani (p. 85, Golius) gives the cubic contents of the six spheres as 107, 90, 72, 54, 36, 18 times that of the Earth. Abu'l Faraj, p. 199, gives a similar series from 93 to $15\frac{1}{4}$ for the average star of each class. Shems ed-din of Damascus in his *Cosmography* (p. 3) merely says that the smallest fixed star is much larger than the Earth.
2. According to Suter, p. 77, a writer called Ibn Zura wrote a treatise "On the cause of the light of the stars, though they and the spheres consist of one single substance."
3. The outermost sphere is by the philosopher Ibn Sina (Avicenna) defined as a spherical, single (not composite) body, emanating directly from God and subject to dissolution, endowed innately with circular motion as an expression of its praise of the Creator (Mehren in *Oversigt, K. Danske Vid. Selskab*, 1883, p. 70).
4. The treatise "*On the motion of the 8th sphere*" has never been printed; an abstract is given in Delambre's *Hist. de l'astr. du Moyen Age*, p. 73. Compare a quotation by Ibn Junis, Caussin, *Notices et Extraits*, VII. p. 116.

He imagines a fixed ecliptic (in the ninth sphere) which intersects the equator in two points (the mean equinoxes) under an angle of $23^{\circ} 33' 30''$, and a movable ecliptic (in the eighth sphere), attached at two diametrically opposite points to two small circles, the centres of which are in the mean equinoxes and the radii of which are $=4^{\circ} 18' 43''$. The movable tropical points of Cancer and Capricorn never leave the fixed ecliptic, but move to and fro to the extent of $8^{\circ} 37' 26''$, while two points on the movable ecliptic 90° from the tropical points move on the circumferences of the small circles, so that the movable ecliptic rises and falls on the fixed one, while the points of intersection of the equator and the movable ecliptic advance and recede to the extent of $10^{\circ} 45'$ either way. This is a motion of the eighth sphere, common to all stars, and the Sun will, therefore, sometimes reach its greatest declination in Cancer, sometimes in Gemini. Tabit does not say that the obliquity of the ecliptic is variable, and perhaps it did not occur to him that this would be a necessary consequence of his theory; he only notices the change in direction and amount of the motion of the equinoxes, which, he says, has increased since the days of Ptolemy, when it was only 1° in 100 years, while later observers have found 1° in 66 years. The erroneous value given by Ptolemy was, therefore, mainly responsible for the continuance of the imaginary theory. It is to be observed that Tabit expresses himself with a certain reservation, and seems to think that further observations are necessary to decide if the theory is true or not. His younger and greater contemporary Al Battani was even more cautious, for though he repeats the account of the trepidation given by Theon (which he says that Ptolemy *manifeste in suo libro declarat*¹) he does not make use of it, but simply adopts 1° in 66 years (or $54''.5$ a year), which he finds by a comparison between his own observations and some made by Menelaus. In rejecting the erroneous value of Ptolemy, which Al Fargani alone had accepted,² Al Battani was followed by Ibn Jünis, who came still nearer to the truth by adopting 1° in 70 years or $51''.2$ a year, and who does not allude to trepidation. It is greatly to the credit of several other Arabian writers that they were not led astray by this imaginary phe-

1. Cap. 52, (205). Plato's translation gives the period as 84 years, but Nallino's ed. has 80 (p. 127).

2. c. 13, p. 49.

3. Schjellerup, *Descr. des étoiles fixes*, p. 43.

nomenon; among them are Al Sufi, the author of the only uranometry of the Middle Ages³, who followed Al Battani, also Abu 'l Faraj and Jagmini,¹ while Nasir ed-din mentions it but seems to doubt its reality.² By others it was willingly accepted, for instance by Al Zarkali, who made the period of oscillation of 10° either way equal to 2000 Muhammedan years (or 1940 Gregorian years, i.e. 1° in 97 years or $37''$ a year). The motion is in a circle of 10° radius; at the Hijra the movable equinox was it $40'$ in increasing precession, and in A. D. 1080 at $7^\circ 25'$.³ The diminution of the inclination of the ecliptic, which the astronomers of Al Mamun had found= $23^\circ 33'$, no doubt lent countenance to the idea of trepidation, and the next step in the development of this curious theory was the combination of progressive and oscillatory motion. Al Betrugi, who gives a sort of history of the theory, beginning with a mythical H mes, makes out that Theon (or Taun Alexandrinus as he calls him) combined the motion of 1° in 100 years with the oscillation³. A century later this was actually done, and the theory received its last development by King Alfonso or his astronomers, who⁴ perceived that the equinoxes had receded much further than Tabit's theory allowed. The equinoxes were now supposed to pass right round the heavens in 49,000 years (annual motion= $26''.45$), while the period of the inequality of trepidation was 7000 years, so that in a sort of Great Jubilee year everything was again as it had been in the beginning.⁵ The progressive motion belongs to

1. Abu 'l Faraj, p. 12, simply says that the motion is 1° in 100 years according to Ptolemy, or 1° in 66 years according to others. But on p. 18 he says that if the ancient Chaldeans gave the tropical points a motion backwards and forwards, and if ancient astrologers adopted this, then the motion of the fixed stars must have been unknown to them. Jagmini (p. 229) says that most people adopt 1° in 66 solar years.
2. *Spheres celestes*, p. 347.
3. Sedillot, *Memoire sur les instr. astr. des Arabes*, pp. 31, 32. Abraham ben Chija (p. 196 of Munster's *Sphaera mundi*. Basle, 1546) gives the period as 1600 years without quoting any authority. He adds that the ancient Indians, Egyptians, Chaldeans, Greeks, and Latins first proposed the theory—Ptolemy neither approved nor disapproved of it, but Al Battani confuted it.
4. Alpetragius, f. 12a. He says that Al Zarkali did the same.
5. A later writer, Augustinus Ricius, *De motu octave sphaere*, Paris, 1521, who traces the theory back to Hermes, 1985 years before Ptolemy (!) credits

(Continued on next page)

the ninth sphere; the annual precession varies between $26''.45 \pm 28''.96$, or from $+ 55''.41$ to $-2''.51$.¹ It was now necessary to assume the existence of a tenth sphere, which as *primum mobile* communicated the daily rotation to all the others, while the ninth produced the progressive and the eighth periodical motion on the small circles, which are situated "in the concavity of the ninth sphere." This was a nice and comfortable theory on account of the long periods involved and the slow changes it produced in the amount of annual precession; and oblivious of the fact that the theory had no foundation except the circumstance that the obliquity of the ecliptic was now about $20'$ less than it had been stated to be by Ptolemy, and that he had given the amount of precession as $36''$ a year instead of about $50''$, and often shutting their eyes to several of the necessary consequences of it, such as the changes in the latitudes of stars which it ought to produce², astronomers continued to accept the theory until at last a real observer of the stars arose and wiped it out by showing that the obliquity of the ecliptic had steadily diminished, and that the amount of annual precession had never varied. We have in this place only alluded to it because it involved some rearrangement of the spheres and because it is eminently characteristic of the period during which no persistent observations were taken, and hardly an attempt was made to improve the theories of Ptolemy. The theory of *trepidatio* or *titubatio*, as it was sometimes called, was one attempt and it would have been better left alone. But it forms a not uninteresting chapter in the history of astronomy.

(Continued from previous page)

this development to a Jew of Toledo, Isaac Hassan (see above. p. 38), adding that Alfonso four years after the completion of the tables became convinced of the futility of the theory by reading the book on the fixed stars by Al Sufi. Riccioli, *Almag. novum*, I. p. 166.

1. In the Alfonsine Tables the maximum took place at the birth of Christ. In Essler's *Speculum astrologicum*, p. 224 (appended to Purbach's *Theoricae novae*, Basle, 1573) the epoch is A.D. 15, diebus 137 completis. Reinhold in his commentary to Purbach (Paris, 1558, f. 163b) explains that $26''.45$ is the space passed over by the Sun in 10 mins. 44 secs., by which amount the Alfonsine Tables made the tropical year smaller than $365\frac{1}{4}$ days.
2. Abraham ben Chija (p. 103, *Schrackenfuhs*) says that trepidation does not change the latitudes. Perhaps he refers to the earliest form of the notion, that described by Theon of Alexandria.

Here we finish our review of ancient astronomy. We have omitted as not coming within our province several valuable contributions to science which did not deal with cosmology or planetary theory. But even with this limitation enough has been said to show that when Europeans again began to occupy themselves with science they found astronomy practically in the same state in which Ptolemy had left it in the second century. But the Arabs had put a powerful tool into their hands by altering the calculus of chords of Ptolemy into the calculus of sines or trigonometry, and hereby they influenced the advancement of astronomy in a most important manner.

References

1. Peter Doig : *A Concise History of Astronomy* London 1950.
1. J.L.E. Dreyer : *A History of Astronomy from Thales to Kepler* Dover publications, 1953 (chapter XI reproduced).
3. Satya Prakash : *Founders of Sciences in Ancient India*, Delhi, 1965.

Personal References of Brahmagupta

Sudhākara Dvivedi in his *Gaṇaka Tarāṅgiṇī*, a small book on biographical sketches of astronomers and astrologers of this country gives a brief account of Brahmagupta thus :

Brahmagupta was born in 520 Śaka (655 Vikramī or 589 A.D.) in the reign of King Vyāghramukha, belonging to the *Cāpa* family ; his father was Jīṣṇugupta ; and at the age of 30, he wrote in 550 Śaka (628 A. D.) his well known treatise on Astronomy known as the *Brāhmasphuṭasiddhānta*, which is corroborated by the statement in the *Viṣṇudharmottara Purāṇa*, (Chapter on the *Brahma-siddhānta*). His other treatise, entitled the *Khanda-Khadyaka*, which is a *karāṇa* book, was completed in 587 Śaka (665 A. D.). According to some authorities, Brahmagupta was the grandson of Viṣṇugupta, and the family suffix (*Gupta*) indicated that he belonged to the Vaiśya family, and he was in the service of the King of Rewah, known as Vyāghrabhaṭa.

Brahmagupta was a great critic ; he did not spare any of his predecessors like Āryabhata, Varāhamihira, Śriṣeṇa, Viṣṇucandra and others. Later on, his influence on the writing of the succeeding generations has been immense. Bhāskarācārya II in his *Bijagaṇita* has acknowledged him as a great authority on algebra and has given him as the first place amongst the galaxy consisting of Brahmagupta, Śridhara, Padmanābha etc. The Eighteenth Chapter of the *Brāhmasphuṭasiddhānta*, known as Kuṭṭaka Chapter (on Pulveriser) has been translated by H. T. Colebrooke in English in 1817. The English translation of the Twelfth Chapter on Gaṇita or Calculations from the *Brāhmasphuṭasiddhānta* is also available in English. (See Colebrook's *Algebra with Arithmetic and Mensuration from the Sanskrit of Brahmagupta and Bhāskara*, London, 1817).

The *Vāsanā Commentary* on the *Brāhmasphuṭasiddhānta* by Pṛthudakavāmi (860 A. D.) is also available though with difficulty (as indicated by Sudhākara Dvivedi) ; its incorrect manus-

cript is available in the Library of the King of Banaras (Kāśirā'a) which has the colophony at the end as :

श्री चापवंशतिलके श्री व्याघ्रमुखे नृपे शकनृपालात् ,
पञ्चाशत्संयुक्तैर्वर्षशतैः पञ्चभिरतीतैः ।
ब्राह्मस्फुटसिद्धान्तः सज्जनगणितज्ञगोलवित्प्रीत्यै,
त्रिशद्वर्षेण कृतो जिष्णुसुतब्रह्मगुप्तो न ॥

Bhāskara II has written the famous treatise *Siddhāntasiromani* (1150), which is almost based on the *Brāhmasphuṭasiddhānta*. It has been edited by the author's own gloss (*Vāsanābhāṣya*) by Bāpu Deva Śāstri (Vārāṇasi); by Murlidhar Jha with the commentaries, *Vāsanāvarttika* of Nṛsimha (1621) and Marici of Muniśvara (1635), vol. I (containing chapter 1 of the *Gaṇitadhyaya*) (Vārāṇasi, 1917); by Girija Prasad Dvivedi with original commentaries in Sanskrit and Hindi, vols. I and II (Lucknow, 1911, 1926); English translation of the text only by Bāpu Deva Śāstri and Wilkinson (Calcutta, 1861).

In the very first Chapter (verse 2), Brahmagupta writes : The old calculations dealing with planets (i.e. the old astronomy), based on the system of Brahmā have become erroneous in course of past ages and therefore, I, the son of Jiṣṇugupta would like to clarify them.

Brahmagupta was not a mere theorist, he based his calculations on direct observations with the help of instruments or devices (*nalikādi yantra*); he was in favour of making corrections on the basis of these observations. He was himself an expert *observer*. In his *Khaṇḍakhadyaka* also he has emphasised the need of direct observation.

At many places, Brahmagupta has severely criticised the Romaka and Pauliśa systems of astronomy which were introduced in this country by Lāṭadeva and Śriṣeṇa. There are many passages where this criticism would be available with vehemance.

Brahmagupta was opposed to the system of Āryabhaṭa I. He never spares the school of Āryabhaṭa which was regarded as the most authoritative then. Sudhākara Dvivedi says that as Brahmagupta was opposed to the system of Āryabhaṭa, so the Vāteśvara Siddhānta was opposed to that of Brahmagupta. The Institute has already published the *Vāteśvara Siddhānta* and now it has the privilege of publishing the *Brāhmasphuṭasiddhānta*.

A Note on Bhillamāla

It is said that Brahmagupta completed his *Brāhmasphuṭa-siddhānta* in Śaka 550, and he has come to be known as Bhillamālākācārya or a teacher residing in "Bhillamālaka." In this connection, therefore, it would be interesting to reproduce a note on *Bhillamāla* from G. Bühler's article on *Gurjara Inscriptions*, No. III, published in the *Indian Antiquary*, July 1888, vol. 17, p. 192 :

With a single exception all the complete inscriptions call the princes enumerated above, scions of the Gurjara race; and *Khe* I. and II. highly extol the greatness and wide extent of this family. *Na.* alone names the Mahārāja Karṇa as their ancestor. With respect to this personage it is for the present impossible to say whether the famous hero of the *Mahābhārata* may be meant, or some real historical king. But the name *Gurjara* makes it evident that this dynasty belonged to the great tribe which is still found in Northern and Western India and after which two provinces, one in the Bombay Presidency and one in the Pañjāba, have been named. The Gurjaras or *Gūjars* are at present pretty numerous in the western Himālaya, in the Pañjāba and in Eastern Rājputānā. In Kachh and Gujarāt their number is much smaller. It would, therefore, seem that they came into Western India from the north. Their immigration must have taken place in early times, about the beginning of our era or shortly afterwards. In Western India they founded, besides the kingdom of Broach, another larger state which lay some hundred miles further north. Hiuen Tsiang mentions in his travels¹ the kingdom of *Kiu-che-lo* and its capital *Pi-lo-mi-lo*. It has been long known that the former word corresponds to Gurjara.

But the name of the town has been incorrectly connected by the French scholars with Bālmér in the Jēsalmír territory, and this identification has been accepted in Mr. Beal's new translation of *Siyuki*. As I have stated already formerly² following Colonel. J. Watson, *Pilomilo* corresponds exactly to Bhillamāla

1. Beal, *Siyuki*, Vol. II, p. 269f. Hiuen Tsiang assigns to the northern Gurjara State an extent about double of that given for the kingdom of Broach.

2. *Ante*, Vol. VI, P. 63.

one of the old names of the modern Bhīnmāl or Śrīmāl¹ in southern Mārvād close to the northern frontier of Guṛarāt. Another work, which was composed a few years before Hiuen Tsiang's visit to Guṛarāt, contains likewise a notice of this northern kingdom of the Gurjaras. The astronomer, Brahmagupta, who completed his *Siddhānta* in Śaka-Samvat 550 or 628 A.D. calls himself Bhīllamālakakācārya², "the teacher residing in Bhīllamālaka and is called so by his commentator Prthūdakaśvāmin. He further states that he wrote under king Vyāghramukha who was 'an ornament of the Cāpa race.' This family, whose name recurs in the Haḍḍāla grant of Dharanivarāha³ prince of Vadhvān, thus seems to have been the reigning house of Bhīllamāla. It is most probably identical with the Cāuḍas, Cāvōtakas⁴ or Chāpōtkatas, who from 756 to 941 A.D. held Anhilvād and still possess various small districts in northern Guṛarāt. The Gurjara kingdom of Broach was without a doubt an offshoot of the larger State in the north, and it may be that its rulers, too, belonged to the Cāpa family.

1. Bhīllamāla means etymologically 'the field of the Bhil' and Śrīmāla 'the field of Sri'. The latter name must also be ancient, as the Śrīmālī Brāhmaṇas are called after it. The Jains narrate various, of course incredible, legends, which explain how Śrīmāla came to be called Bhīllamāla. Merutunga says that king Rhoja invented the latter name, because the people of Śrīmāla let the poet Māgha die of starvation. According to another authority, the town had a different name in each Yuga. It is in India very common for ancient towns to have two or even more names. Thus Kanauj was called, Kānyakubja, Gādhīpura, and Mahodaya.

2. See Professor A. Weber, *Die Sanskrit und Prakrit Handschriften der Berliner Bibliothek* Vol. II. pp. 297-298. In the first passage the MSS. offers incorrectly Bhīlamācārya; in the second which occurs in the commentary on the Khaṇḍakhādyaka, we have Bhīllamālavakācārya, a slightly corrupt reading. This latter varia lectio occurs also in other MSS., see Weber, *Indische Streifen*. Vol. III, p. 90, and has given rise to erroneous suppositions regarding Brahmagupta's home. The Gujarāṭi Joshis still preserve the tradition that Brahmagupta was a native of Bhīnmāla.

3. Ante, Vol. XII. p. 190ff. The remark which I have made there that the Cāpas are not named elsewhere, of course requires correction.

4. The form Cāvōtaka, which occurs in Dr. Bhagavanlal's grant of the Gujarāt Cālukya king Pulakeśin of Samvat 490, is the immediate predecessor of the word Cāuḍa. Its Sanskrit original is certainly not cāpōtkata which probably has been coined in comparatively speaking modern times, in order to explain the difficult Prakrit word, just as the bards of Rajputana have invented Rāṣṭraudha as etymon for Rāṣṭhoḍ.

Brahmagupta's own References

In the Twenty-fourth Chapter (*Saṅjñādhyāya*), of the *Brāhmasphuṭasiddhānta*, Brahmagupta has made a reference to his own biography: In the reign of Vyāghramukha belonging to the family of Cāpa, in the year 550 Śaka the treatise *Brāhmasphuṭasiddhānta* was composed for the benefit of benevolent astronomers by Brahmagupta, son of Jīṣṇugupta at the age of 30. (*BrSpSi*. XXIV. 7. 8)

Then again he says: The *Brāhmasphuṭasiddhānta* has been written by Brahmagupta, son of Jīṣṇu, in 1008 verses of Āryāchanda. (*ibid* 10)

In the beginning of this *Saṅjñādhyāya*, he refers to the differences in fundamental notions created by the various existing systems of astronomy as the *Sūrya-siddhānta*, *Pulisa-siddhānta*, *Romaka-siddhānta*, *Vasiṣṭha-siddhānta* and other *Yavana-siddhāntas*, which have caused anomalies in the calculations of eclipses. He also refers to the anomalies due to the calculations based on midnight day-reckoning and sunrise day-reckoning.

From the point of view of own references, the following would be of interest:

Brahmagupta, son of Jīṣṇugupta (Jīṣṇusuta-Brahmagupta):
BrSpSi. I. 2; XVI. 35. 37; XXIV. 8. 10; XXV. 73.

It is strange that in the *Khaṇḍakhādyaka*, Brahmagupta has not given his name nor his father's name anywhere. At least the reading of the *Khaṇḍakhādyaka* as given by Pṛthūdakasvāmī does not contain this name. In the edition of Bhaṭṭotpala, there are three more chapters in the *Khaṇḍakhādyaka* (Chapters IX, X and XI). In the Chapter XI (known as *Paṭādhikāra*), we have 21 verses and in the last 21st verse we find the name of Brahmagupta,¹ son of Jīṣṇu mentioned:

Those who are eager to have the knowledge of the motion of stars and planets, for them and for the benefit of disciples in this field, Brahmagupta son of Jīṣṇu has composed this *Khaṇḍakhādyaka*.

1. खण्डखाद्यकमिदं तृप्त्यर्थं ग्रहगतिबुधार्त्तानाम् ।

शिष्याणां हितार्थं प्रोक्तं जिष्णुसुतब्रह्मगुप्तेन ॥

Reference to Āryabhata

We have said that it appears that Brahmagupta was a bitter opponent of Āryabhata in his younger days (623 A. D.), but later on (in 665 A. D.), he climbed down to describe and teach one of the Āryabhata's system of astronomy. Āryabhata was universally revered, and it was difficult for Brahmagupta to have ignored him and thus he has to refer to this great authority some times to oppose some of his views and some times to expound his views. The following are the passages in the *Brahmasphuṭasiddhanta*, where the author has referred to the name of Āryabhata. There are many other passages where the name "Āryabhata" does not occur but where Brahmagupta indirectly means to quote the views of this great master.

BrSpSi. I. 9. 12. 28. 32. 60. 61 ; II. 33. 46; V. 21.25; VI. 13; IX.10; XI. 4. 9. 10. 12. 25. 29. 33. 41. 42. 43. 44. 46. 47. 49. 62; XIII. 27; XIV. 45; XVI. 37. 46; XXI. 39.

The largest references are in Chapter XI, where Brahmagupta has made an attempt to show the discrepancies of the Āryabhatīya system of reckoning astronomical observations and constants.

In the *Khaṇḍakhadyaka* also there is a reference to the name of Āryabhata but on very few occasions. In Chapter I, we have this reference at three places-

Having made obeisance to God Mahādeva, who is the great cause of this world's rise (i.e. creation), existence and destruction, I shall declare the *Khaṇḍakhadyaka* (i.e. a short treatise on astronomy, which is as pleasant as food prepared with sugarcandy), which will yield the same results as the great astronomical treatise of Āryabhata. As in most cases calculation by the great work of Āryabhata, for (the knowledge of time and longitude of planets etc. at) marriage, nativity and the like, is impracticable for common use every day, this smaller treatise is made so as to yield the same results as that. ¹

1. प्रणिपत्य महादेवं जगदुत्पत्तिस्थितिप्रलयहेतुम् ।
वक्ष्यामि खण्डखाद्यकमाचार्यार्यभट्ट दुर्लभफलम् ॥
प्रायेणार्यभटेन व्यवहारः प्रतिदिनं यतोऽशक्यः ।
उद्वाहजतकादिषु तत्समफललघुतरोक्तिरतः ॥

These two verses show that Brahmagupta was not hostile to Āryabhāṭa when he wrote this *Khaṇḍakhādyaka*; he merely intends presenting the subject matter on simple lines and furnishing the results obtained by Āryabhāṭa in a simpler way.

In the following verse of the same chapter, he refers to Āryabhāṭa's midnight day-reckoning system :

The mean Saturn diminished by 3 seconds, the Śighrocea of Mercury diminished by 22 seconds, the mean Mars increased by 2 seconds and the mean Jupiter increased by 4 seconds are equal to the respective mean planets of Āryabhāṭa's "midnight-system".¹

In the Appendix of the *Khaṇḍakhādyaka* known as *Khaṇḍakhādyakottara*, we again find a few verses where the name of Āryabhāṭa occurs; Three of these verses have been reproduced from the *Brāhmasphuṭasiddhānta* (*BrSpSi* I. 62, 63; II.47) :

Āryabhāṭa made the apogee of the Moon as moving more quickly and the node as moving more slowly than their actual motions; if his constants give correct results in relation to the end of *tithis* [i. e. conjunction etc.] or eclipses, they must be considered as accidental as are the letters cut into wood by weevils. (*KK*. IX.1; *BrSpSi*. I. 62)

On seeing me, who possess the most accurate knowledge of mean motions, men who have learnt from the works of Śriṣeṇa, Viṣṇucandra and Āryabhāṭa, cannot face me in any meeting just like deer on seeing a lion (*KK*. IX. 2; *BrSpSi*. I. 63)

As the apparent planets beginning with Mars as derived from the works of Śriṣeṇa, Āryabhāṭa and Viṣṇucandra, are far deviated from their true places, the works of these authors are therefore not valued among the learned.² (*KK*. IX. 3; *BrSpSi*. II. 47)

1. तिसृभिः शनिर्बृहस्पतिं द्वाविंशत्या कुजोऽधिको द्वाभ्याम् ।

चतसृभिरधिको जीवोऽर्द्धं रात्रिकार्य्यभटमव्यसमाः ॥

—*KK*. I. 7

2. अकृतार्य्यभटः शीघ्रगमिन्दूच्चं पातमल्पं स्वगतेः ।

तिथ्यन्त ग्रहणानां घुणाक्षरं तस्य संवादः ॥१॥

मध्यगतं वीक्ष्य श्रीषेणार्य्यभट विष्णुचन्द्राः ।

सदसि न भवन्त्यभिमुखाः सिंहं दृष्ट्वा यथा हरिणाः ॥२॥

दूरभ्रष्टाः स्पष्टाः श्रीषेणार्य्यभटविष्णुचन्द्रेषु ।

यस्मात् कुजादयस्ते विदुषां नैवादरस्तस्मात् ॥३॥

—*KK*. IX. 1-3

In the Appendix of the *Khaṇḍakhādyaka*, there is another verse which also speaks in the same strain against Āryabhaṭa (this verse does not occur in the *Brāhmasphuṭasiddhānta*) :

As the process of finding the apparent places of planets as given by Āryabhaṭa does not make them agree with observation, I shall, therefore, speak of this process. Of the Sun the apogee is at two signs and seventeen degrees (*KK. IX. 4*)¹

Brahmagupta opposed to Śriṣeṇa—

Viṣṇucandra, Lāṭa, Vijayanandī and others

Brahmagupta was a great critic; he did not spare Āryabhaṭa, and along with him he was vehemently opposed to the doctrine of Śriṣeṇa, Viṣṇucandra, Lāṭadeva, Vijayanandī and Pradyumna also. He was opposed to the *Romaka* and *Paulīśa Siddhāntas*, which were the systems of foreign astronomy, derived from Greece, Babylonia and other centres of learning. He did his best to resist the foreign influences on astronomy.

The following are the verses in the *Brāhmasphuṭasiddhānta*, where Brahmagupta expressed his note of discord against the systems or notions of Āryabhaṭa, Śriṣeṇa and Viṣṇucandra :

BrSpSi. I.60; II 46, 47; X 13, 62; XI.31, 46, 47, 48-50, 55, XVI. 36, 46; XXI.39; XXII. 2.

In two of the verses he refers to Lāṭasimha :

BrSpSi. XI. 46, 48.

In the following verse, he refers to Anḱaciti, Vijayanandī, Pradyumna and others: *BrSpSi. XI. 58.*

In the *Khaṇḍakhādyaka* we do not find the names of these adversaries of Brahmagupta ; we, however, have a reference of Śriṣeṇa, Āryabhaṭa and Viṣṇucandra in the verses already quoted, occurring in the Appendix of the *Khaṇḍakhādyaka* (*Khaṇḍakhādyakottara*), Chapter IX. 2 and 3. As we have said before, these verses of the Appendix have been reproduced from the *Brāhmasphuṭasiddhānta*. (I.62 and II.47).

Reference to Romaka and Paulīśa systems

Brahmagupta speaks of his system as if expounded by Brahmagupta himself for the first time, later on deteriorated, and then revived by Brahmagupta himself. The very second verse of the *Brahma-*

1. न स्युद्धमार्थमयोक्तं स्पष्टीकरणं यतस्ततो वक्ष्ये ।

भानुमतो मन्दोच्चं राशिद्वयमंशकाश्च सप्तदश ॥

sphuṭasiddhānta (I. 2) substantiates this view :

The science of astronomy (or the calculations of heavenly bodies) in course of long duration became ineffective or erroneous; this was revived by Brahmagupta, son of Jīṣṇu.¹ (*BrSpSi*. I.2).

The system of astronomy which goes by the name Brahma (*Brahmasiddhānta*) has been handed down to us in three forms : (i) one is as treated by the *Śākalya Samhitā*, (ii) one as described in prose in the *Viṣṇudharmottara Purāṇa*, and (iii) the one described by Varāhamihira in the *Pañcasiddhāntikā*, which recognises the *yuga* of the duration of five years. Which of these three was accepted by Brahmagupta is not clear. But from the measures of the number of revolutions performed by a planet in a given period (*graha-bhagaṇa*) etc., it is clear that Brahmagupta acknowledges the system as propounded in the *Viṣṇudharmottara Purāṇa*. In his chapter "*Tantra-parikṣādhyāya* or *Dūṣaṇādhyāya*", he contradicts the notions of the *Vedāṅga Jyotiṣa* which accepts the *yuga* of five years.

We may further emphasize the fact that Brahmagupta has not clearly detailed out the errors to which the Brahma-siddhānta succumbed in course of time, and how these errors were eradicated by him. During the days of Brahmagupta, Romaka and Pauliśa systems were getting currency in this country. Reference to these two are found in the *Brāhmasphuṭasiddhānta* at several places as follows :

ROMAK : I.13; XI.50; XXIV.3

PAULIŚA : XIV.45; XXIV.3

In fact, *BrSpSi*. XXIV.3, we find the line "*Sūryendu-Puliśa-Romaka-Vasiṣṭha-Yavanādyaiḥ*", where we have a reference to all the then existing systems : *Sūrya-siddhānta*, *Indu-siddhānta*, *Puliśa-siddhānta*, *Vasiṣṭha-siddhānta*, and other *Yavana-siddhāntas*. Just as the Sun is one, so the astronomical system is also one; this is a different thing that calculations in different systems may vary according to different sunrises in different places.

Brahmagupta refers at one place to Varāhamihira in *BrSpSi*. XXI.39, where he has been spoken of in connection with a list of

१. ब्रह्मणोक्तं ग्रहगणितं महता कालेन यत् खिलीभूतम् ।

अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन ॥

—*BrSpSi*. I. 2.

anti-authoritative versions of astronomical systems :

Evam Varāhamihira-Śriṣenācāryabhaṭa-Viṣṇucandrādyañ

Lokaviruddhamabhihitam Veda-smṛtisaṃhitābāhyam.

At one place, he mentions the difference between the calculations based on the system of Āryabhaṭa and the Pañca-siddhāntas (Five systems) : Pauliśa, Romaka, Vasiṣṭha, Saura, and Paitāmaha. (*BrSpSi*. XIV.46).

Brahmagupta was also familiar with the Jaina systems of astronomy; for example, at one place he uses the term "Jinoktam" (i.e., one propounded by the Jainas) : He repudiates the concept of *two Suns and two Moons* "*Dvāvarkaindavau*" (do canda do suiṇa) (*BrSpSi*. XI.3) as enunciated by the Jainas.

At several places we find a reference to the *Vasiṣṭha-siddhānta* (*BrSpSi*. XI.49, 50; XXIV.3)

Wherever, Brahmagupta has to press for his views in preference to the views of others, he uses the words *Brāhma* or *Brahmokta* : *BrSpSi*.

Brāhma : I.32; X.62; XI, 61; XVI.37

Brahmokta : II.31, 33; X.63, 69; XV.59; XVI.33

Reference

Sudhākara Dvivedi : *Gaṇaka Taraṅgiṇi*

G. Bühler : *Gurjara Inscriptions, Indian Antiquary*, 1888.

P. C. Sengupta : *Khaṇḍakhadyaka*, Calcutta, 1934.

CHAPTER III

Manuscripts of the Brāhmasphuṭa Siddhānta

Sudhākara Dvivedī has given an account of some of the manuscripts of the *Brāhmasphuṭasiddhānta* in his *Bhūmika* or Introduction appended to the edition published in the PANDITA, Vol. XXIV, 1902 (New Series) : (i) available in the Library of the Government College, Kashi (Varāṇasi) i. e. Kāśika-Rājakiya-Pāṭhālaya, (ii) Dr. Thibaut's Manuscript, (iii) the Manuscript in possession with Yajñadatta Sharmā, the Chief Astronomer attached to the Prince of Ayodhyā. It is further mentioned that Dr. Thibaut's Manuscript was a copy of a Manuscript available in the Deccan College, Poona. The Manuscripts (ii) and (iii) were identical. The Manuscripts (iii) was very faulty and incorrect.

The Manuscript from which Colebrooke translated out in English the Twelfth and the Eighteenth Chapters on *Gaṇita* or Mathematics and *Kuttaka* (the Chapter on Pulveriser) respectively, appeared to be different from the three Manuscripts described above. The readings differed considerably. The *Kuttaka* Chapter of that book is, writes Sudhākara Dvivedī, still available in the India Office Library. (See Catalogue of the Sanskrit Manuscripts in the Library of India Office, Part V. p. 995).¹

1. एतत्कृतस्यास्य सिद्धान्तग्रन्थस्यैका प्रतिः काशिकराजकीय पाठालयतो द्वितीया डा० थिबौ साहिब महाराष्ट्रतस्तृतीया चाथोध्यानरेशप्रधानज्योतिर्विच्छेद्यह्नदत्तशर्मणो मया लब्धा । डा० थिबौमहाराष्ट्रस्य पुस्तकं कश्चिद्दक्षिणदेशीय (Deccan College, Poona) डेका पुस्तकस्य प्रत्यन्तरम् । इदं पुस्तकं तथा पं० श्री यह्नदत्त पुस्तकं चैकमातृकमेव । इदं पुस्तकत्रयमतीवाशुद्धं बहु च स्वलिप्तं चास्ति ।

यत्पुस्तकानुसारेण व्यक्ताध्यययोर्द्वादशाष्टादशसंख्ययौरेगलभाषायामनुवादः कोलब्रूकसाहिबेन कृतस्तत्पुस्तकमेतत्त्रयतो भिन्नमित्यसंशयं विभाति पाठविभेदात् । तत्पुस्तकस्य कुट्टकाध्यायः संप्रति इण्डिया-आफिस-सरस्वती भवने वर्तते (See Catalogue of the Sanskrit Manuscripts in the Library of India Office, Part V, Page 995)

पृथक्कृताऽस्य सिद्धान्तस्य टीका या कोलब्रूकसाहिबेन भारतवर्षे ह् युपलब्धा सा च संप्रति लखननगरे इण्डिया-आफिस-सरस्वती भवने वर्तते । तस्या एका प्रतिर्नद्वारेणैव श्री डा० थिबौ साहिबमहाराष्ट्रयोःनोत्पादिता सापि संप्रति मन्निक्टेऽस्ति । अहो इण्डिया-आफिस-सरस्वती

(Continued on next page)

Colebrooke procured a Manuscript of the Pṛthudaka Svāmī's Annotation on the *Brāhmasphuṭasiddhānta* from somewhere in India. This is also available in the India office Library, London. Undoubtedly it appears that this Manuscript is a copy from one written in the *Maithila* script. Dvivedī describes a few characteristics of this Manuscript. For example, on the Folio 11. 7 (७) is written instead of 9 (९). At a few other places also, the same has happened. Following a visarga, (*kva* क्व) is inscribed instead of 'ka' (क), for example refer to Folio 12, line 6. At some places instead of *visarga* (:) we find *ṣa* (ष) inscribed, for example on Folio 12, line 1. Sometimes we find a *sandhi* at the *virāma* or end of a sentence; e. g. in the *Golādhyāya*, Folio 21, line 2: *sarvamupapannamuktamakhaṇḍena* (सर्वमुपपन्नमुक्तमखण्डेन). At some places we find *nū* (नू) written in place of *nta* (न्त). In one of the Folios, *Śrī Gaṇeśāya namaḥ*. श्रीगणेशायनमः is written in *Maithila* script.¹ Sudhākara Dvivedī prepared a copy of this Manuscript for Dr. Thibaut, and this copy was available with Sudhākara Dvivedī when he published his commentary with Text in the *Paṇḍita*. During the course of binding, on account of carelessness, many of the Folios got misarranged, and many of them got fragmented. Sudhākara Dvivedī emphasises in his Introduction the need of careful research on the arrangement of these Folios and their readings. (See *Catalogue of the Sanskrit Manuscripts* in the Library of India Office, Part V, p. 993-995).

Sudhākara Dvivedī with considerable efforts could rearrange the Text :

Golādhyāya-Bhāṣyam 1 to 45, mutilated at the beginning
Madhyamādhikāra-Bhāṣyam 45 to 59

(Continued from previous page)

भवने अस्य पुस्तकस्य पुटकबन्धनकालेऽनवधानतया पत्रास्यसंगतानि जातानि, बहुत्र खण्डितानि च सन्ति । तानि कदाचिदनुपयुक्तपत्राणां मध्ये स्थिरिति तेषां सम्यगन्वेषणं समुचितम् । (See *Catalogue of the Sanskrit Manuscripts* in the Library of India Office Part, V, Page 993-995)

1. इदं पुस्तकं कस्यचिन्मिथिलाक्षरैर्लिखितस्य पुस्तकस्य प्रत्यन्तरमिति निःसंशयं प्रतिभाति । ११ पत्रे, ६ इत्यस्य स्थाने ७ इति लेखात् । एवमन्यत्रापि । विसर्गात् परतः 'क' स्थाने 'क्व' इति लेखात् । यथा १२ पत्रे, ६ पंक्तौ । तथा विसर्गस्थाने 'प' इति लेखात्, यथा १२ पत्रे, १ पंक्तौ । बाधय-विरामेपि सन्धिकरणात् । यथा गोलाध्यायस्य २१ पत्रे, २ पंक्तौ सर्वमुपपन्नमुक्तमखण्डेन । कुत्रचित् 'न्त' स्थाने 'नू' इति लेखात् । एकस्मिन् पत्रे मैथिलाक्षरैः श्री गणेशायनमः इति लेखाच्च ।

In this, the commentary is up to verse 31. In the *Spaṣṭādhikāra*, the commentary begins from verse 29. Folio 60. At the top of the Folio, we have the old numbering 1 and 115.

After this, 68 folios are mis-arranged, and there the old numbering is marked 9.

After that, up to 87 folio, we have in the bound volume a commentary up to the verse 6 of *Tripraśnādhikāra*. Here the old numbering is marked 28. Then we have the commentary up to verse 27 of the *Tripraśnādhikāra*. Here the numbering of folios is marked 1 and 159 (old numbering) and 218 new. After this, then we have in the bound volume, commentary up to verse 33 of the *Tripraśnādhikāra*. On the last folio, the old numbering is marked 5 and 163, the new numbering 222. After this begins the commentary on the *Candra-grahāṇādhikāra* from verse 4, old numbering 1 and 297 and new numbering 257. Then follows the commentary on *Sūrya-grahāṇa* up to verse 23. The last old folio numbering is 36 and 232, the new numbering 292. This is the last folio-numbering of the volume in the India Office Library. After this, begins the commentary on *Grahayutyadhikāra*, verse 11, old numbering 1 and 164 and the new numbering 223.

Then follows the *Madhyagatyuttarādhya* up to verse 40, old folio numbering 119, and new numbering 178. Then we have the commentary of the *Madhyagatyuttarādhya* beginning from the verse 45; the old folio numbering 120 and the new numbering 179. Then we have the commentary on *Tripraśnottarādhya* up to verse 56. Here the last old folio number is 48 and 158, and the new numbering 217.

In this way, we have the commentary on : the mutilated *Golādhya*, mutilated *Madhyamādhikāra*, mutilated *Spaṣṭādhikāra*, mutilated *Tripraśnādhikāra*, mutilated *Candra-grahāṇādhikāra*, mutilated *Sūrya-grahāṇādhikāra*, mutilated *Grahayutyadhikāra*, *Bhagrahayutyadhikāra*, *Tantra-parikṣādhya* (also known as *Dūśādhikāra*), *Gaṇitādhya* (Arithmetic), mutilated *Madhyagatyuttarādhya*, *Sphuṭagatyuttarādhya*, mutilated *Tripraśnottarādhya*.¹

1. मया महताऽऽयासेन तत्प्रति-पाठक्रम एवं नियोजितः ।

गोलाध्यायभाष्यम् १-४५ आदौ खण्डितम् ।

मध्यमाधिकारभाष्यम् ४५-५१ ।

(Continued on next page)

Sudhākara Dvivedi says that nowhere in the *Brahma-Sphuṭasiddhānta*, *Madhyamādhikāra*, is found the verse :

*Samsādhyā spaṣṭataram bijam nalikādiyantrena.
Tat-sansṛtagrahebhyaḥ kartavyau nirṇayādeṣau.*

(This verse has been quoted by Dvivedi in the *Gaṇaka-Taranginī*, page 19).¹

This verse has been quoted by Dvivedi from the Translation of *Grahalaghava* by Mallāri.

Dvivedi further says that in the Manuscripts available, there is mentioned a Twenty-fifth Chapter under the title "*Dhyānagrahopadesādhyāya*". Dvivedi thinks that this Chapter does not constitute the *Brahmasphuṭasiddhānta* proper, which ends in fact with twenty-four chapters.² In his commentary and Edition in the *Pandita*, he has published it as a separate treatise of Brahmagupta. Thus he has named his Edition as :

अत्र मध्यमाधिकारे ३१ श्लोकपर्यन्तमेव भाष्यम् ।

अतः स्पष्टाधिकारस्य २६ श्लोकतष्टीकाऽऽख्या ५० पत्रतोऽत्र प्राचीन संख्या पत्रोपरि १, तथा ११५ ।

अग्रेऽत्र ६८ पत्रमसंगतम्, यत्र प्राचीन संख्या ६ ।

ततः ८७ पत्रपर्यन्तं संलग्नग्रन्थस्त्रिप्रश्नाधिकारस्य ६ श्लोकपर्यन्तं टीका । अत्र प्राचीनपत्रसंख्या २८ । तत्त्रिप्रश्नाधिकारस्य २७ श्लोकतष्टीका, पत्रसंख्या प्राचीना १ तथा १५६, नवीना २१८ । अग्रे संलग्न ग्रन्थस्य त्रिप्रश्नाधिकारस्य ३३ श्लोकपर्यन्तं टीकान्तिमपत्रप्राचीनसंख्या ५ तथा १६३, नवीना संख्या च २२२ । ततश्चन्द्रग्रहणाधिकारस्य ४ श्लोक टीकाश्चा प्राचीनपत्रसंख्या १ तथा २६७ । नवीना संख्या च २५७ । ततः सूर्यग्रहणस्य २३ श्लोकपर्यन्तं टीका । अन्तिम प्राचीन पत्रसंख्या ३६ तथा २३२, नवीना संख्या च २६२ । इण्डिया-आफिस पुस्तकपुटके चैयमन्तिमपत्रसंख्या । ततो ग्रहयुत्यधिकारस्य ११ श्लोकतष्टीकाश्चा यत्र प्राचीनपत्रसंख्या १ तथा १६४, नवीना संख्या २२३ । ततो मध्यमगत्याुत्तराध्यायस्य ।

४० श्लोकपर्यन्तं संलग्नग्रन्थौ यत्रान्तिमप्राचीनपत्र संख्या ११६ नवीना संख्या च १७८ । ततो मध्यगत्याुत्तराध्यायस्य ४५ श्लोकतष्टीकाश्चा । अत्र प्राचीनपत्रसंख्या १२० नवीनासंख्या च १७६ । तत्त्रिप्रश्नोत्तराध्यायस्य ५६ श्लोकपर्यन्तं टीका । अत्रान्तिमप्राचीनपत्रसंख्या ४६ तथा १५८, नवीना संख्या च २१७ ।

खण्डितगोलाध्यायस्य । खण्डितमध्यमाधिकारस्य । खण्डितस्पष्टाधिकारस्य । खण्डित-त्रिप्रश्नाधिकारस्य । खण्डितचन्द्रग्रहणाधिकारस्य । खण्डितसूर्यग्रहणाधिकारस्य । खण्डितग्रहयुत्यधिकारस्य । भयग्रहयुत्यधिकारस्य । तन्त्रपरीक्षाध्यायस्य (द्रव्याधिकारस्य) । गणिताध्यायस्य पादो-गणितस्य) । खण्डितमध्यगत्याुत्तराध्यायस्य । स्फुटगत्याुत्तराध्यायस्य । खण्डितत्रिप्रश्नोत्तराध्यायस्य च टीका वर्तते ।

1. सर्वेष्वपि पुस्तकेषु 'संसाध्य स्पष्टतरं बीजं नलिकादिवेत्रेण' इत्यादिश्लोको मध्यमाधिकारे नास्ति । मया गणकतरंगिण्या मल्लारिकृतग्रहलाघवटीकातो व्यलेखि (द्रष्टव्या गणकतरंगियो ५०-१८१६) ।

Brahmasphuṭasiddhānto Dhyānagrahopadesādhyaśca or *Brahmasphuṭasiddhānta* and *Dhyānagrahopadesādhya* by Brahmagupta (1902)¹

The manuscript of this small treatise was also mutilated, and Dvivedī took special pains in editing it, and he revised the calculations also incorporated in this treatise.

The small treatise, *Dhyānagrahopadesādhya* must have been composed prior to the *Brahmasphuṭasiddhānta*, since we find a verse in the last Chapter (the 24th Chapter also known as the *Saṁjñādhya* of the *Brahmasphuṭasiddhānta*), verse 9, a reference to this book :

How could this result be obtained in a simple way has been shown by me in the *Dhyānagrahopadesādhya* of 72 Āryā verses, and therefore, it is not repeated here. *BrSpSi*. XXIV. 9)

In the *Dhyānagrahopadesādhya*, we have a verse 61, which is also found in the *Khaṇḍakhādyaka* (KK. I. 21) :

Navatithayaḥ (159) divided by *aṣṭi* (16), *pañcarasāḥ* (65) divided by *vasu* (8), 10 divided by 3, each multiplied by the equinoctial shadow are the (tabular differences of) ascensional difference expressed in *vinādis*. (KK. I. 21; *DhGr*. 61)

This verse then indicates that the *Dhyānagrahopadesādhya* has been composed after the *Khaṇḍakhādyaka*. It may also be possible that the *Brahmasphuṭasiddhānta* and the *Dhyānagrahopadesādhya* were simultaneously written, and the above verse (*DhGr*. 61) was repeated again in the *Khaṇḍakhādyaka*.

Sudhākara Dvivedī has taken the help from the commentary of Pṛthūdaka Svāmī in the Chapters on *Paṭiganita* (Arithmetic), and has quoted the examples from this commentary. At many places he has corrected the readings which were mutilated in manuscripts.

1. उपलब्धमूलपुस्तकत्रये पञ्चविंशतितमेध्याये वस्तुतो ब्रह्मगुप्तकृतो ध्यानग्रहोपदेशाध्यायो वर्ततेऽतो मयायं पृथक्त्वेन तन्नाम्ना मुद्रितः । अत्र बहुत्र रखलितानि पदानि तानि गणितेन संशोध्य मुद्रितान्यपि सुधीभिर्भृशं विचिन्तयानि ।

अस्य सिद्धान्तस्य चतुर्विंशतितमेऽन्तिमे संज्ञाध्याये (पृ० ४०८)

गणितेन फले सिद्धिर्ब्राह्मे ध्यानग्रहे यतोऽध्याये ।

ध्यानग्रहो द्विसप्ततिरायोणां न लिखितोऽत्र मया ॥

इति नवमश्लोकेन ध्यानग्रहोपदेशाध्यायस्य रचनेतत्सिद्धान्तरचनातः पूर्वं विभाति परन्तु तत्राहर्गणसाधनप्रकरणेयं सिद्धान्तरचनाकाल एवास्य रचना स्थिति तथा 'नवतिथयोष्टिविभक्ता' इत्यादि-गणने खण्डखाद्यरचनातः पश्चात् सिध्यति ।

Reference

Sudhākara Dvivedī : His *Bhūmika* on *BrSpSi.*, *Pandita*,
Vol. XXIV, 1902 (New Series)

—: ० :—

Subject Matter Classified in the Brāhmasphuṭasiddhānta & Khaṇḍakhādya

It needs no emphasis that Āryabhaṭa commanded a great influence as an astronomer not only prior to Brahmagupta but during his days also, and we have seen how Brahmagupta quoted this great authority in his writings, sometimes borrowing from him and sometimes contradicting him or improving upon his calculations. Āryabhaṭa's great work is known as the *Aryabhaṭīyam* written in 499 A. D. Āryabhaṭa was born in 476 A. D. (Kaliyuga Saṃvat 3577). The *Aryabhaṭīyam* is also known as the *Aryasiddhānta*. For details about Āryabhaṭa the reader is referred to the Chapter entitled "Āryabhaṭa lays Foundations of Algebra" (*Founders of Sciences in Ancient India*, 1965, Chapter X). This great work was written in Kusumapura, (modern Patna, Bihar).

Divisions of Āryabhaṭīyam

The *Aryabhaṭīyam* is divided into four chapters called *Pada*: (i) the *Gitika Pada*, with ten verses; (ii) the *Gaṇita Pada* with 33 verses; (iii) the *Kalakriyā Pada* with 25 verses and (vi) the *Gola Pada* with 50 verses.

In the *Gaṇita Pada*, a chapter on mathematics, we have such subjects : squares (*varga*), cubes (*ghana*) (verse 3), square-root (*vargamūla*) (4), cube-root (*ghanamūla*) (5) ; area of a triangle, volume of a prism (6), area of a circle, volume of a sphere (7), area of a quadrilateral (*viṣamacaturasra*) (8); circumference of a circle (10), Rsine (radius x sine) (*Jīva*) (11); determination of the Rsine of the zenith distance, the base (*bāhu*) of a right-angled triangle, and the upright (*koṭi*) of a right-angled triangle (16) ; hypotenuse (*kārṇa*) of a right-angled triangle and *ardhajyā* (17), Reversed-sine (*śara*) (18), areas of series-figures (*śreḍhīphala*) (19), rule of three (*trairāśika*) (23), reduction of fractions (*savarṇanikaraṇa* of *bhinnā*) (27) ; inverse-rule of three (*vyasta*) (28) ;

evaluation of unknown values (*mūlya-pradarśana* of *avyakta mūlya* (30); and the theory of pulveriser (*Kuṭṭaka*) (32, 33). In this chapter, Āryabhaṭa gives the solutions of quadratic equations, and thus he earns for himself the credit of founding the science of algebra.

(iii) The *Kalakriyā Pāda* with 25 verses, which enumerates the units of time [1 year (*varṣa*)=12 months (*māsa*); 1 month=30 days (*divasa*); 1 day=60 *nāḍis*; 1 *nāḍi*=60 *vināḍi*; *vināḍi* or *vināḍikā* is the same as *vighaṭikā* equivalent to our 24 seconds; *nāḍi* or *nāḍikā* or *ghaṭi* is equal to 24 minutes]¹; correlation of time division with the *kṣetra*—division or angular division.² Twelve signs of Zodiac or *rāśis* go to constitute a *bhagaṇa*³; solar day (*ravimāsa*), lunar day (*śasi māsa*); additional month or intercalary month (*adhimāsa*); various kinds of years: the solar year is human or *manuṣya* year; 30 human years=1 *pitṛ* year; 12 *pitṛ* years=1 *divya* year (divine year); 12,000 *divya* years constitute a *yuga* (6, 7, 8); the first half of the *yuga* is *utsarpiṇī kālā*, and the latter half is *avasarpiṇī kālā* and they are calculated from the apex of the Moon (*candrocca*) (this is not very clear) (9); a *yuga* is of 60 years, and such 60 *yugas*, that is 3,600 years had passed away since the *kalīyuga*, when the author was of 23 years of age, (10); the count of a *yuga*, year, month and

१. वर्षं द्वादशमाससित्ररादिवसो भवेत् स मासस्तु ।
षष्टिनोड्यो दिवसषष्टिस्तु विनाडिका नाडी ॥

—Ārya. III. 1.

२. गुर्वक्षराणि षष्टिर्विनाडिकार्द्धी षडेव वा प्राप्याः ।
एवं कालविभागः क्षेत्रविभागस्तथा भगण्यात् ॥

—Ārya. III. 2.

यावता कालेन षष्टिगुर्वक्षराण्युच्चरति मध्यमया वृत्त्या पुरुषः ।
तावान्काल आर्द्धी विनाडिका । ...यावता कालेन पुरुषः
षडुच्छ्वासान् करोति, तावान्कालश्चार्द्धी विनाडिका स्यात् ।
(परमादीश्वर)

Just as we have the time division, similarly we have the *kṣetra* division or the circular angular division. A year has twelve months, so do we have 12 *rāśi* in a *bhagaṇa*. One-thirtieth of a *rāśi* is one *bhaga*; one-sixtieth of a *bhaga* is one *liptā*; one-sixtieth of a *liptā* in one *viliptā*; and one-sixtieth of a *viliptā* is one *tatpara*.

३. चन्द्रोऽशौर्द्वादशभिर्विचित्रोऽकांस्तरस्थितैर्हस्यः ।
नवभिर्गुप्तुर्गोस्तेर्द्वाधधिकैर्यथारलक्षणाः ॥

—Ārya. IV. 4.

day should begin from the month *Caitra Śukla Pratipadā* (the first day of the brighter half of the month *Caitra*) (11); *mandocca* (apex of slowest motion) and *śighrocca* (apex of fastest motion) (17—24).

(iv) The *Gola Pāda* with 50 verses. In Verse 1, there is a reference to a point in the Sun's path, the commencement of *meṣa* (*meṣādi*); this must have been *vasanta*-equinox. The ascending nodes (*pāta*) of planets and the shadow of the Earth move on the path of the Sun (*arka-apamaṇḍala*) (2-3); the angular difference in relation to the Sun at the appearance of Moon (12 degree or *aṁśa*), of the Venus (9 degrees or 9 *vinādikā*); of the Jupiter (2 more than the Venus, i.e. 11 *vinādikās*); the Mercury or *Budha* (13 *vinādikās*), of the Saturn or *Śani* (15 *vinādikās*); and of Mars or *kuja* (17 *vinādikās*).

The half of the Earth, Moon, planets and stars is dark, since those parts happen to be under their own shadow; the other half is bright as it faces the Sun (this is not true with respect to stars—author) (5). The Earth is surrounded with an atmosphere of air and water (6, 7). In the *Brahma-Divasa* (Brahma's day), the sphere of the Earth is increased by one *yo'ana* and decreased by this amount during the Brahmā's night (8). Just as a person sitting on a moving boat sees the stationary trees etc. on the bank of a river moving in the opposite direction, similarly the stationary stars are seen moving from *Lankā* (or equator) moving towards the West (9). On account of *pravahavāyu* (air) the *nakṣatra* system and planets rise and set receding towards the West (10). The dimensions of *Sumeru Parvata* (North pole) is given to be one *yojana*, and it shines like a jewel (11) and in the next verse is given the position of *Sumeru* and the *Bāḍa-vamukha* (South pole) (12). The four cities situated at a difference of 90° each on the equator are given (13). The distance of *Ujjayini* from *Lankā* (thus giving the latitude of *Ujjayini*) is given (14).

On account of the thickness of the Earth-sphere, the *Khagola* (celestial sphere) is seen less than the hemisphere (15). The next verse describes how moving appears the *Khagola* on the North and South poles (16). Then is given the measure of day and night of *devas* (gods), *pitar* (fathers), *asura* (demons) and *manuja* (men) (17). Then are given a few technical definitions

of celestial mathematics (18—21) like *dr̥ṣṭi-sthāna* (intersection of horizontal and vertical axis—*pūrvapardiggatā rekhā* and *adhar-urdhva-diggatā rekhā*). *Dr̥ṣṭi-maṇḍala*, *dyṅkṣepamaṇḍala* (*dyṅkṣepa* is the zenith distance of that point of a planet's orbit which is at the shortest distance from the zenith). Then the *Bhūbhagola* instrument is described (22, 23). Then follow the formulæ for calculating *lagna* (the horizon ecliptic point in the East), *kula* etc. comprising the *Tripraśnādhikāra* (24—33). In the next verses, we have *lambaka* or Rsine of colatitude (34); *dyṅk-karma* (35) and *ayana-dyṅk-karma* (36). Then follow the calculations of lunar and solar eclipses (37—47). Verse 48 describes the coordinates of the Sun which are determined by the conjunction of horizon with the Sun, of the Moon by the conjunction of the Sun and the Moon, of planets by the conjunction of the Moon and planets or stars. Verse 49 describes how this jewel treatise has been procured out of an ocean of true and untrue knowledge with the help of a boat of intellect. This means that the author has taken special pains in discriminating true knowledge from falsehood with respect to the prevalent notions of astronomy. In the last verse he says that he has not given anything new; he has given that very knowledge which was imparted by the *Svayambhu* in the earliest times (50).

The *Pañchāṅgas* prepared according to the rules and formulæ of the *Āryabhaṭīyam* are still regarded with reverence by the *Vaiṣnavas* in the South. Brahmagupta was a great critic of Āryabhaṭa, but finally he wrote his treatise, the *Khaṇḍakhadyaka*, on the basis of this very *Āryabhaṭīya* (this treatise is a *karaṇa-grantha* i.e. one containing a principal element of the Indian Calendar). The four commentaries of the *Āryabhaṭīya* available in Sanskrit are of Bhāskara I, Sūryadeva Yajvā, Paramēśvara and Nīlakanṭha. Two English translations by P.C. Senagupta (1927) and W.E. Clark (1930) are also available.

Major Landmarks

Indian astronomy which reached its zenith in the times of Āryabhaṭa and Brahmagupta shows its evolution in the following stages:

1. Rudiments of astronomy in the *Vedas* and *Brahmana*. Books like the *Taittirīya Samhita* and the *Śatapatha Brahmana*. This period is associated with the dis-

covery of the Vedic era, some of the planets, the twenty-four *nakṣatras*, cycle of seasons, concept of leap year, the dimensions of a yuga, solar and lunar years and the like.

- II. Astronomy of the *Ādāṅga*, also known as the *Ādāṅga Jyotiṣ*. Lagadha is the most prominent figure of this period (1400 B.C. to 850 B.C.) ; he is the first compiler of a text on astronomy. In his work, we for the first time in history find a reference to the *Jñeya Rāsi* (the knowable or the unknown quantity) and the *Jñāna-Rāsi* (known quantity). He lays the foundations of astronomical calculations. In his treatise we find a mention of such subjects as : Solstices (northern and southern journey of the Sun), increase in days and nights in the *āyanas* or solstices, solstitial *tithis* omission of *tithis*, *parva rāsi*, acceptable and non-acceptable *parvas*, addition of day, acceptable *parvas*, concept of *yoga* (a term applied to the joint space which would be travelled by the Sun and the Moon in a given period of time on the presumption that these two bodies have travelled in directions opposite to each other), method of finding out a *nakṣatra* on any *parva* day, distinction between *parva-nakṣatra* and *tithi-nakṣatra*, correlation of solar and lunar dates, measure of a *nādikā* (unit of time), *nakṣatra* of the Sun, *yoga* and its *nakṣatra*, *parva-bhaṣeṣa* and equivalent *kalās*, solar year, lunar revolutions (risings of *nakṣatras*) deities of *nakṣatras*, lunar and *sāvāna day* differences (*ahika māsa*), divisions of a *sāvāna day* and length of day in two *āyanas*. This author probably belonged to Kashmir.
- III. The period of *Siddhāntas* : Varāhamihira in his well known treatise, the *Pañcasiddhāntikā*, refers to five *Siddhāntas* or systems of Astronomy : Paitāmaha, Vasiṣṭha, Romaka, Pauliśa and Sūrya (Saura). As regards its importance, he gives the first place to the Sūryasiddhānta, places next the Romaka and Pauliśa, and declares the remaining two to be definitely inferior to the former. We do not possess the full treatise of these *Siddhāntas*, except the *Sūryasiddhānta*. Here too,

we have difficulty. The *Sūryasiddhānta*, as summarised by Varāhamihira in his *Pañcasiddhāntikā*, in many essential features differs from the system prescribed by the Text of the *Sūryasiddhānta* now available. So we have two versions, the one with which Varāhamihira was familiar and the modern one.

The present *Sūryasiddhānta* comprises of fourteen chapters called *adhyāyas*. We have an authentic commentary on it by Parameśvara. The first two chapters of the *Sūryasiddhānta* have no special name. The classification of chapters is as follows :

Modern Sūrya Siddhānta

Chapter	Name of the Chapter	Number of verses	Subject
I	—	69	Mean longitude of planets.
II	—	68	True motion and true longitude of planet ; and elements of <i>Pañcāṅga</i> .
III	Tripraśnādhyāya	50	Directions, place and time.
IV	Candra-grahaṇādhyaṃyāya	29	Lunar eclipse.
V	Sūrya-grahaṇādhyaṃyāya	17	Solar eclipse.
VI	Chedyakādhyāya	24	Projection of eclipse on a plane surface.
VII	Graha-samāgama-yuddhādhyāya	24	Conjunction of one planet with another.
VIII	Tārāviśayodhyāya	21	Conjunction of a Planet with the junction star of a nakṣatra.
IX	Udayāstamaya-viśayodhyāya	18	Heliacal rising and setting of planets.
X	Candrāstamayādi viśayāḥ	16	Moon rise and elevation of Moon-horn.
XI	Vyatipāta-viśayāḥ	23	Pāta (<i>vyatipāta</i>)
XII	—	87	Cosmogony and geography

Chapter	Name of the Chapter	Number of verses	Subject
XIII	Vyatipāta-viṣayāḥ	26	Armillary sphere and astronomical instruments
XIV	—	28	Modes of reckoning time
	Total	500	

From the contents of the Modern *Sūryasiddhānta*, it appears that its great author (or rather *compiler*, since this *Siddhānta* has been existing much before he compiled this treatise) intends giving a complete but brief account of the entire Indian astronomy. He has been careful enough to avoid controversies, and he has omitted the methods occurring in other *Siddhāntas* and *Mahā-tantras* as alternative rules. He describes only those which are most important and of general nature. Part II of the book dealing with cosmogony and geography etc.. is very brief, and the entire subject has been summarised in three chapters (Chapters XII to XIV). The Chapter on Astronomical instruments (XIII) is sketchy and rather incomplete; the author has given the names only of the instruments, as if the purpose was to keep the details secret and guarded. The whole text of the *Sūryasiddhānta* is finished in 500 verses (compare this with the length of other Indian books on Astronomy: the *Brāhmasphuṭasiddhānta* 1008 verses, the *Siddhānta-sekhara* 890 verses and *Siddhānta-siromaṇi* proper 962 verses).

The Modern *Sūryasiddhānta* is a composition or compilation of a period when the *Āryabhaṭīyam* and the *Brāhmasphuṭasiddhānta* had already become popular. This *Sūryasiddhānta* is indebted to both these systems, though it has nowhere acknowledged them in the Text. We shall refer to this matter later at an appropriate stage of our discussion.

It may casually be mentioned here that Alberuni has ascribed the authorship of the *Sūryasiddhānta* to Lāṭādeva while Munīśvara (603 A. D.) has ascribed it to Āryabhaṭa I. Though there is little or no support to these views, it is not improbable, that the works of Āryabhaṭa I and Lāṭādeva which followed mid-night-day-reckoning were based on the *Sūryasiddhānta* prevalent at the time. P. C. Senagupta on the other hand is of the opinion that "the old *Sūryasiddhānta* was made up-to-date by Varāhamihira by replacing the old constants in it by new ones from Ārya-

bhaṭa I's midnight system. " In this connection, it must be remembered that Varāhamihira nowhere expresses his indebtedness to Āryabhaṭa I.

The *Sūryasiddhānta* undoubtedly is the most popular book on Astronomy in this country. It has been so for the last 1000 years as is seen from the list of commentators on its text (K. S. Sukla has given a list of 28 commentators including those who wrote commentaries in the South Indian languages like Telugu and Kannaḍa.):

Allanarya Suri	Maheśvara
Amareḍya	Mallikārjuna Suri (1178 A. D.)
Bhaṭṭotpala (966 A. D.)	Nārāyaṇa
Bhūdhara (1572 A. D.)	Nrsinha Daivajña (b. 1586 A.)
Bhūti viṣṇu	Nṛsiṃhadeva
Caṇḍeśvara (1178)	Parameśvara (1432 A. D.)
Cola	Raghava Śarmā (1592 A. D.)
Dādābhai (1719 A. D.)	Ramakṛṣṇa Ārādhya (1472 A. D.)
Devidāsa	Raṅganātha (1603 A. D.)
Kamala Kara Daneśvarah (1618 A. D.)	Sārvabhauma
Kāmaabhaṭṭa	Tamma Yajva (1599 A. D.)
Kṛṣṇa Daivajña	Yallaya (1472 A. D.)
Madanapāla	Viśvanātha (1628 A. D.)
Mādhavācārya	

A large number of astronomical books in this country were written on the basis of the *Sūryasiddhānta*, as the *Gaṇakananda* by Sūrya (1387-1447 A. D.), *Gaṇitadarsa* by Dharmapathin, *Makaranda Sārīṇi* by Makaranda (1478 A. D.), *Grahaçakra* by Kucanācārya (1299 A.D.), *Viṣṇukaraṇa* by Viṣṇu (1556 A.D.) besides many others with indefinite dates such as the *Sūryasiddhānta nayana-prakāraḥ*, *Sūryasiddhānta-gaṇita Sūryasiddhānta-saṃgraha* by Viśvanātha Suri, and *Sūryasiddhānta Sārīṇi* by Rāmadatta Daivajña. K. S. Sukla has given a list of this literature in his Introduction to the *Sūryasiddhānta*.

(iv) *Period of Bhāskara I*: The author or the compiler of the *Sūryasiddhānta* is not known nor its date of composition. Bhāskara and Brahmagupta are the brilliant names of a contemporary period. Bhāskara I lived in the seventh century of the Christian era and was a contemporary of Brahmagupta (628

A.D.). He wrote three works on Astronomy which were most likely composed in the following order : (i) the *Mahā-Bhāskariya*. (ii) a commentary on the *Āryabhāṭiya*, and (iii) the *Laghu-Bhāskariya*. His commentary on the *Āryabhāṭiya* was written in 629, i.e., only one year after the *Brāhmasphuṭasiddhānta*. His commentary on the *Āryabhāṭiya* was written in 629 A.D., i.e., one year after the completion of the *Brāhmasphuṭasiddhānta*. Undoubtedly Bhāskara was the follower of Āryabhaṭa I. Shukla says, that his works provide us with a detailed exposition of the astronomical methods taught by Āryabhaṭa I and throw light on the development of Astronomy in India during the sixth and early seventh centuries A. D. which was the most brilliant period in the history of Indian Astronomy-Shukla has brought a critical edition with English translation of the *Mahābhāskariya* and the *Laghu-Bhāskariya* and he proposes to bring out a volume on the life and works of this great astronomer.

Division of Mahābhāskariya

The *Mahābhāskariya* is divided into Chapters called the *adhyāyas*. The *adhyāyas* have not been named as some of the Chapters of the *Sūryasiddhānta* or the *Brāhmasphuṭasiddhānta*. The number of verses in the *Mahābhāskariya* is as follows :

	Subject	Number of verses
Adhyāya I	Mean Longitude of a Planet and Planetary Pulveriser	52
Adhyāya II	The Longitude Correction	10
Adhyāya III	Direction, Place and Time. Junction-stars of the Zodiacal Asterisms and conjunction of Planets with them.	75
Adhyāya IV	The Longitude of a Planet	64
Adhyāya V	Eclipses	78
Adhyāya VI	Rising, Setting and Conjunction of Planets	62
Adhyāya VII	Astronomical Constants	35
Adhyāya VIII	Examples	27

These titles to the subject-matter given in the above table have been assigned by Dr. Kripa Shanker Shukla in his critical

edition. The total number of verses in this work is 403. The *Sūryasiddhānta* has, as stated above, 500 verses in all.

Laghu-bhaskariya

The *Laghu-Bhāskariya* is also divided into eight chapters, each chapter is known as *Adhyāya*. The subject matter in the book has been dealt with as follows :

Subject			Number of verses
Adhyāya	I	Mean longitudes of the Planets	37
Adhyāya	II	True Longitudes of the Planets	41
Adhyāya	III	Direction, Place and Time from Shadow	35
Adhyāya	IV	The Lunar Eclipse	32
Ādhyāya	V	The Solar Eclipse	15
Adhyāya	VI	Visibility, Phases and Rising and Setting of the Moon	25
Adhyāya	VII	Visibility and Conjunction of the Planets	10
Ādhyāya	VIII	Conjunction of a Planet and a Star	19

The total number of verses in this text is 214. The *Laghu-Bhāskariyam* is thus an abridged edition of the *Mahā-Bhāskariyam*. From the closing stanza of this work, it is clear that the author wrote this work for the benefit of young students with immature mind by condensing and simplifying the contents of his larger work, the *Mahā-Bhāskariyam* (also known as *Karma-nibandha*). Thus we have a little of the parallelism: Brahmagupta, after finishing his bigger treatise, the *Brahma-sphuṭasiddhānta*, wrote a minor abridged work, the *Khaṇḍa-khādyaka*, as a *karana grantha*. This latter work of Brahmagupta, however, incorporates some original ideas not included in the earlier work. Shukla has given an analytical table indicating the rules of the *Mahā-Bhāskariyam* incorporated in the *Laghu-Bhāskariyam* also in an abridged or modified form, and also a list of the rules which have been omitted in the *Laghu-Bhāskariya*. There are a few rules in the *Laghu-Bhāskariya* also which have no counterpart in the

Mahā-Bhāskariya. Shukla further says that the arrangement of the contents of the *Laghu-Bhāskariya* is more systematic and logical than that of the *Mahā-Bhāskariya*, and is, at the same time, in keeping with the general practice followed by the other Hindu astronomers. Numerous quotations of this work occur in the annotative works of Sūryadeva (b. 1191 A.D.), Yallaya (1480 A.D.), Nilakaṇṭha (1500 A.D.), Raghunātha Rāja (1597 A.D.), Govinda Somayājī and Viṣṇu Śarmā and in the *Prayogaraśanā*, an anonymous commentary on the *Mahā-Bhāskariyam*. We find the commentaries of this abridged work in Malayalam and Tamil also. All this speaks of the great popularity of this work.

There are circumstantial evidences to show that Bhāskara I had associations with the countries of Aśmaka and Surāṣṭra. His commentary on the *Āryabhaṭiya* was probably written in the city of Valabhī in Surāṣṭra. Perhaps Bhāskara I was born and educated in Aśmaka and later on he migrated to Valabhī, where he wrote his commentary on the *Āryabhaṭiya* or that he was a native of Valabhī and got his education in the Aśmaka country. Perhaps there was a strong school of Astronomy in the Aśmaka country, which was founded by the followers of Āryabhaṭa, so much so that at places, Bhāskara I has also called Āryabhaṭa as Āśmaka, his *Āryabhaṭiym* by the name *Aśmaka-Tantra* or the *Āśmakiya* and the followers of Āryabhaṭa as *Āśmakiyāḥ*. This Aśmaka country or Aśmaka Janapada is mentioned in the Buddhist literature also. It was somewhere either in the north-west of India, or was situated between the rivers Narmadā and Godāvarī. Bhāskara I was evidently a resident of the latter Aśmaka (which was between the Narmadā and Godāvarī).

Brahmagupta and Bhāskara I were contemporaries. Both of them developed their systems in the earlier part of the seventh century A.D. (3700 years of *Kaliyuga*). *Brahmasphuṭasiddhānta* was written in 628 A.D. and the commentary on the *Āryabhaṭiym* by Bhāskara I was composed in 629 A. D. Bhāskara closely followed Āryabhaṭa, but Brahmagupta had the guts to oppose the views expressed by this great master and he not only contradicted him at places, but also propounded many new ideas, methods of calculation and constants of greater accuracy.

The classification of the contents of Astronomy in *adhikāras* appears to be the original concept of *Brahmagupta*; this system was to some extent adopted in the modern *Sūrya-Siddhānta* in the case of a few chapters. The *Vaṭeśvara-Siddhānta* by Vaṭeśvarācārya (born 802 Śaka or 880 A.D. in Ānandapura city, Punjab, son of Mahādatta) also adopts the terminology: *Madhyamadhikāra*, *Spaṣṭādhikāra* and *Tripraśnādhikāra*. We owe this type of caption-nomenclature to Brahmagupta.

Contents of the Brahmasphuṭasiddhānta

Now we shall summarise the contents of the Chapters of this great treatise and also enumerate the number of verses in each chapter. The author has himself given the total number of verses in the Chapter in the ending verse of each chapter. Sometimes, the verse specifying this number itself is not taken into account while giving the total number of verses in that chapter, and therefore, there occurs a minor discrepancy in the actual number and the number specified by the author himself. The following table records both these numbers separately :

Chapter	Title	Number of verses indicated by the author	Actual number of verses
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PURVA-DAŚĀDHYĀYI (First Ten Chapters)

I	Madhyāmadhikārah (Madhyamagati-radhyāyah)	63	63
II	Spaṣṭādhikārah (Sphuṭagati-radhyāyah)	67	68
III	Tripraśnādhikārah (Tripraśnādhhyāyah)	66	66
IV	Candragrahaṇādhikārah (Candragrahaṇādhhyāyah)	20	20
V	Sūryagrahaṇādhikārah (Ārka-grahaṇam or Ravigrahaṇādhhyāyah)	26	27
VI	Udayāstādhikārah (Udayāstamayādhhyāyah)	12	13

VII	Candraśṛṅgonnatyadhikāraḥ (Candraśṛṅgonnati-adhyāyaḥ)	18	18
VIII	Candracchāyādhikāraḥ (Candracchāyā-adhyāyaḥ)	9	9
IX	Grahayutyadhikāraḥ (Grahamelanādhyaḥ)	26	26
X	Bhagrahayutyadhikāraḥ (Bhagrahayutiḥ-adhyāyaḥ)	70	70
	Total (of Daśādhyaḥ)	377*	380*
XI	Tantra-Parikṣādhyaḥ (Dūṣaṇādhyaḥ)	63	63
XII	Gaṇitādhyaḥ Mīśraka-vyavahāraḥ 1—16 Śreḍhī-vyavahāraḥ 17—20 Kṣetra-vyavahāraḥ 21—39 Vṛttakṣetra-gaṇitam 40—43 Khāta-vyavahāraḥ 44—46 Citi-vyavahāraḥ 47— Kākacika-vyavahāre karaṇasūtre 48—49 Rāśi-vyavahāraḥ 50—51 Chāyā-vyavahāraḥ 52—66	66	66
XIII	Praśnādhyaḥ (Madhyagatyuttarādhyaḥ)	49	48
XIV	Sphuṭagatyuttarādhyaḥ	54	55
XV	Tripraśnottarādhyaḥ	60	60
XVI	Grahaṇottarādhyaḥ	46	47
XVII	Śṛṅgonnatyuttarādhyaḥ	10	10
XVIII	Kuṭṭādhyaḥ (Kuṭṭakādhyaḥ) Kuṭṭākāraḥ 1—29 Dhanarṇa-śūnyānām saṃkalanam 30—42 Ekavarṇa-saṃikarṇa- bijam 42—50 Anekavarṇa-saṃikarṇa-	103	102

	bijam	51—59	
	Bhāvita-bijam	60—63	
	Varga-prakṛtiḥ	64—74	
	Udāharaṇāni	75—102	
XIX	Śāṅkucchāyādi-ñānādhyāyaḥ	20	20
XX	Chandaścityuttarādhyāyaḥ	20	19
XXI	Golādhyāyaḥ	70	70
	Sāmānya-golaprakara-		
	ṇam	1—16	
	Jyā-prakaraṇam	17—23	
	Sphuṭagati-vāsanā	24—30	
	Bimba-sādhanaṁ	31—35	
	Grahaṇa-vāsanā	36—48	
	Golabandhādhikā-		
	raḥ	49—70	
XXII	Yantrādhyāyaḥ	53	57
XXIII	Mānādhyāyaḥ	12	12
XXIV	Sañjñādhyāyaḥ	13	13
		<hr/>	<hr/>
	Total	1016	1022

In one of the verses, Brahmagupta states that he has composed the treatise containing 1008 verses. Sudhākara Dvivedī has given the total as 1021, whereas he says, this number according to Brahmagupta's own statement should be 1020. If one deducts the concluding 12 verses of the *Sañjñanādhyāya*, the number should be 1008.

Sudhākara Dvivedī, in his addition of the *Brahma-sphuṭa-siddhānta* (published in the *Pañḍita*, 1901 and 1902) gives as a supplement a small treatise of Brahmagupta known as *Dhyānagrahaṇopadesādhyāya* or *Dhyānagrahaṇādhikāraḥ* which has 72 verses.

It would be worthwhile to give here the details of the *Khaṇḍakhādyaka* also, a book of Brahmagupta about which we have spoken so much. The titles to the chapters have not been indicated in the Text; most likely they have been assigned by the commentator, Pṛthūdaka Svāmī known as the *Khaṇḍakhādyaka-vivaraṇam*.

Chapter	Title	Number of verses
I	Tithi-nakṣatrādhikārādhyaḥ (On tithis, nakṣatras etc.)	32
II	Grahagatyadhyāḥ (On the mean and true places of 'star' planets)	19
III	Tripraśnādhyaḥ (On the three problems relat- ing to diurnal motion)	16
IV	Candragrahaṇādhyaḥ (On lunar eclipses)	7
V	Sūryagrahaṇādhyaḥ (On solar eclipses)	6
VI	Udayāstādhikārah (On the rising and setting of planets)	7
VII	Candrasṅgonnatyadhāḥ (On the position of the Moon's cusps)	4
VIII	Samāgamādhyaḥ (On conjunction of planets)	6
UTTARA KHAṆḌAKHĀDYAKA—APPENDIX		
IX	Corrections and new methods	14
X	On conjunction of stars and planets	16
Total		127

Bhaṭṭotpala, in his commentary on the *Khaṇḍakhādyaka* has given several additional verses in the main or proper treatise and also in its Uttara portion or the Appendix. P.C. Sengupta's edition (Sanskrit Text 1941) has given at the end of this publication the account of these additional verses. The English

edition (1934) classifies the *Uttara-Khaṇḍakhadyaka* into two chapters (which the author calls as Chapters IX and X), the Sanskrit edition gives 3 verses in Chapter IX, 21 verses in Chapter X and 24½ verses in Chapter XI. Of these three chapters, the Chapter X has been given the title "*Paṭadhikara*" and Chapter XI the title "*Parilekhaḍhyāya*" by Bhaṭṭotpala.

TABLE

Arrangement of contents in different treatises

Topic	BrSpSi	SūSi	MBh	MSi	SiSe	SiSi
Mean longitudes of the planets	I,XIII	I	I	I,II	I,II	I
True longitudes of the planets	II,XIV	II	IV	III	III	II
Direction, place and time	III,XV	III	III	IV	IV	III
Computation of a lunar eclipse	IV,XVI	IV	V	V	V,VII	IV,V
Computation of a solar eclipse	V,XVI	V	V	VI	VI	VI
Projection of an eclipse	XVI	VI	V	VIII		V
Conjunction of a planet with another planet	IX	VII	VI	XI	XI	X
Conjunction of a planet with a star	X	VIII		XII	XII	XI
Heliacal rising of planets	VI	IX	VI	IX,X	IX	VII, VIII

Topic	BrŚpSi	SūSi	MBh	MSi	SiŚe	SiŚi
Moonrise and elevation of lunar horns	VII, XVII	X	VI	VII, VIII	X	IX
Pata	XIV	XI	VII	XIII	VIII	XII
Cosmogony and geography	XXII	XII		XVI		II.iii
Astrono. instruments	XXIII	XIII	III		XIX	II.xi
Time reckoning	XXIV	XIV				I.i

Āryabhaṭa and Brahmagupta Controversy

The scientific Indian astronomy was more or less created by Āryabhaṭa I (476 A. D.). It is said that he was the teacher of two distinct systems of astronomy, one of which is called the *audayika* system, and the other the *ardharātrika* system. In the first, the astronomical day is taken to begin at *sunrise* at Lāṅkā, and in the other, the same begins at the *midnight* of the same place. In the *Khaṇḍakhādya* Brahmagupta gives compendious rules for the calculation of longitudes, etc, of planets according to the *ardharātrika* system of Āryabhaṭa I. In this connection, he refers to Āryabhaṭa in the following words in his *Khaṇḍakhādya* :

Having made obeisance to God Mahādeva, who is the great cause of this world's rise (i. e. creation), existence, and destruction, I shall declare the *Khaṇḍakhādya* which will yield the same results as the great astronomical treatise of Āryabhaṭa.¹

As in most cases calculation by the great work of Āryabhaṭa, for (the knowledge of time and longitude of planets etc. at) marriage, nativity and the like is impracticable for common use every day, this smaller

1. प्रणिपत्य महादेवं जगदुत्पत्तिस्थितिप्रलयहेतुम् ।
वक्ष्यामि खण्डखाद्यकमाचार्यार्यभट्टतुल्यफलम् ॥

treatise (i.e. *Khaṇḍakhādyaka*, literally meaning food prepared from sugar-candy) is made so as to yield the same results as that.¹

The mean saturn diminished by 3 seconds, the *Śighrocca* of Mercury diminished by 22 seconds, the mean Mars increased by 2 seconds and the mean Jupiter increased by 4 seconds are equal to the respective mean planets of Āryabhaṭa's *midnight* system.²

In the *Brāhmasphuṭasiddhānta*, Brahmagupta accepts the astronomical day to begin with the sunrise at Lāṅkā, and the calculations of days, months, years, Yugas, and Kalpas all begin from Caitra Śukla Pratipadā (the first *tithi* of the month Caitra in the bright-half of the Moon) and the first day is regarded as Sunday.³

Varāhamihira in his epicyclic cast to the *Sūryasiddhānta* in his *Pancasiddhāntikā* adopts the *ardharātri* system or the system of reckoning days from midnight. The question why Brahmagupta who was so bitter an opponent of Āryabhaṭa I in his younger days (628 A.D.) claimed down to describe and teach one of the systems of Āryabhaṭa's astronomy in his sixty-seventh year (665 A.D.) is difficult to explain. In fact so great was Āryabhaṭa's reputation and fame that in spite of Brahmagupta's severe ricticisms of the former in Chapter XI of the *Brāhmasphuṭasiddhānta*, it perhaps was undiminished and it was Āryabhaṭa who continued to be universally followed.

Some authorities have thus expressed the view that to meet the popular demand Brahmagupta in the *Khaṇḍakhādyaka* took upon himself the task of simplifying Āryabhaṭa's *ardharātri* system and in this task he became eminently successful. But it has been supposed that in this task he could not be a mere simplifier or expounder.

प्रायेणार्थमटेन व्यवहारः प्रतिदिनं यतोऽश्वयः ।

उद्वाहजतकादिषु तत्समफलं लघुतरोक्ति रतः ॥

त्रिस्त्रिंशतिः शनिर्द्विंशतिः द्वारिंशत्या कुजोऽधिको द्वाभ्याम् ।

चतस्रश्चिःसधिको जीवोऽर्द्धरात्रिकार्यमट मध्य समाः ॥

१. त्रिस्त्रिंशतिर्द्वयद्भानोर्दिनमासवर्षयुगकल्पाः ।

सूच्यादौ लंकायां समं प्रवृत्तः दिनेऽर्कस्य ॥

—KK. I. 1,2,7

—BrSpSi I.4

The minor work of Brahmagupta known as *Khaṇḍakhādyaka* has two distinct parts : *Khaṇḍakhādyaka* proper and the *Uttara Khaṇḍakhādyaka*. In the first part the astronomical constants are the same as those of Āryabhaṭa's *ardharātriśa* system, but the methods of spherical astronomy, calculation of eclipses and other topics are almost the same as in the *Brāhmasphuṭasiddhānta*. The corrections for parallax in calculating a solar eclipse is here an important illustration.¹

In the *Uttarakhaṇḍakhādyaka*, Brahmagupta gives corrections to the *Khaṇḍakhādyaka* proper. In it are to be found the neat and original methods of interpolation and correction to the longitudes of the aphelia, as also to the dimensions to the epicycles of apsis of the Sun and the Moon.² while a few additional chapters supply what else is necessary to the first seven chapters of the first part, to make the whole a complete treatise on Indian scientific astronomy. It was perhaps through the influence of this supplementary part of the *Khaṇḍakhādyaka* that Brahmagupta's great work, the *Brāhmasphuṭasiddhānta* came to be valued among a distinct school of Indian astronomers. For long in this country India, this *Siddhānta* of Brahmagupta has been forming the basis for the calculation of almanacs by astronomers of the orthodox school of Rājasthān, Bombay and others.

We might at this stage take up the question : Was Āryabhaṭa the author of two distinct systems of astronomy ? Undoubtedly he was. Several authors have written on this subject. I may specially mention the name of Prabodha Chandra Sengupta (*Journal of the Department of Letters, Calcutta University*, vol. XVIII; *Bulletin, Calcutta Mathematical Society*, vol. XXII. Nos. 2 and 3). The reasons advanced by him may be restated in slight details thus. In his *Brāhma-*

1. व्यासार्धेन विभक्ता दृग्गतिर्जीवा चतुर्गुणा लब्धम् ।
लम्बननाड्यः पञ्चदश गुणितया त्रिज्यया भक्ता ॥
दक्षेपज्या मुह्यन्तरा हता लब्धमवनतिर्भवति ।
स्फुट्योजनकर्णान्यां भू-यासेन च विना स्पष्टे ॥
आर्यभटेनारिमन् सति लघुनि किमर्थं महत् कृतं कर्म ।
गणितानानाज् जाड्यं विज्ञानता यदि ततः सुतराम् ॥

—*BrSpSi*. XI. 23-25, also *KK*. V.

sphuṭasiddhānta, Brahmagupta thus speaks of the two works of Āryabhaṭa:

As in both the works the number of the Sun's revolutions is spoken of as 432,000 years, their planetary cycle is clear, i. e., of 4,320,000 years. Why then is there difference of 300 civil days in the same cycle of the two books ?¹

Again, he says :

In 14,400 years elapsed of the *Mahāyuga*, there is produced a difference of one day in the *audayika* and *ardharātri* systems.²

Varāhamihira in the *Pañcasiddhāntikā* writes -

Āryabhaṭa maintains that the beginning of the day is to be reckoned from midnight at Lankā; and the same teacher again says that the day begins from sunrise at Lankā.³

Thus from the writings of Brahmagupta and Varāhamihira, it is clear that Āryabhaṭa I was the author of both the *audayika* and *ardharātri* systems of astronomy. In Varāhamihira's verse the phrase *sa eva* (स एव), meaning "he undoubtedly" is of special significance. It removes the least doubt as to Āryabhaṭa's authorship of both these systems. The *audayika* and *ardharātri* astronomical constants are respectively to be found from the Āryabhaṭīya and may be deduced from the *Khaṇḍakhadyaka* as well. The following is the comparative view of the constants of Varāhamihira and of the present day *Sūrya-siddhānta*.

TABLE I

Planetary revolutions in a mahāyuga of 4,320,000 years, according to various authorities.

1. युगरविमगणाः रव्युदृति क्त् प्रोक्तं तत् तथोयुगं स्पष्टम् ।

त्रिरात्री रभ्युदयानां तदन्तरं हेतुना केन ॥

—BrSpSi XI. 5

2. अधिकैः शतैश्चतुर्भिर्वर्षं सप्तसूश्चतुर्दशभिरेकः ।

युगायातैर्दिनवान्तरं मौदयिकार्धं रात्रिकयोः ॥

—BrSpSi XI. 13

3. लङ्काद्धरात्रसमये दिनप्रवृत्तिं जगाद चार्यभटः ।

भूयः स एव सूर्योदयात् प्रभृत्याह लङ्कायाम् ॥

—PSi, XV. 20

Planet	<i>BrSpSi</i>	<i>Āryabhaṭya</i>	<i>Khaṇḍa- khādyaka</i>	<i>Varāha- Sūrya- siddhānta (PSi.)</i>	Later or modern <i>Sūrya- siddhānta</i>
Moon	57,753,300	57,753,336	57,753,336	57,753,336	57,753,336
Sun	4,320,000	4,320,000	4,320,000	4,320,000	3,320,000
Mars	2,296,828.522	2,296,824	2,296,824	2,296,824	2,296,832
Jupiter	364,226.455	364,224	364,220	364,220	364,220
Saturn	146,567.298	146,564	146,564	146,564	145,568
Moon's apogee	—	488,219	488,219	488,219	488,203
Venus	7,022,389.492	7,022,338	7,022,388	7,022,388	7,022,376
Mercury	17,936,998.984	17,937,020	17,937,000	17,937,000	17,937,060
Moon's nodes	232,311.168	232,226	232,226	232,226	232,238

TABLE II

Longitudes of the apogees of the orbits of Planets.

Planets	<i>Āryabhaṭya</i>	<i>Khaṇḍa- khādyaka</i>	<i>Varāha- Sūrya-sid- dhānta.</i>	<i>Modern Sūrya-siddh- ānta</i>
Sun	78°	80°	80°	77° 07'
Mercury	210°	220°	220°	220° 26'
Venus	90°	80°	80°	79° 49'
Mars	118°	110°	110°	130° 00'
Jupiter	180°	160°	160°	171° 16'
Saturn	236°	240°	240°	236° 37'

TABLE III

Dimensions of the epicycles of Apsis

Planets	<i>Āryabhaṭya</i>	<i>Khaṇḍa- khādyaka</i>	<i>Varāha. Sūrya- siddhānta</i>	<i>Modern Sūrya- siddhānta</i>
Sun	13°-30'	14°	14°	13½°-14°
Moon	31°-30'	31°	31°	31½°-32°
Mercury	22½°-31½°	28°	28°	28°-30°
Venus	9°-18°	14°	14°	11°-12°
Mars	63°-81°	70°	70°	72°-75°
Jupiter	31½°-36½°	32°	32°	32°-33°
Saturn	40½°-58½°	60°	60°	48°-49°

Table IV

Dimensions of the Sighra epicycles (i.e. conjunctions)

Planet	Āryabhaṭīya	Khaṇḍa- Khādyaka	Varāha Sūrya- siddhānta	Modern Sūrya- siddhānta
Saturn	36½°- 40°	40°	40°	39°- 40°
Jupiter	67½°- 72°	72°	72°	70°- 72°
Mars	229¼°-239½°	234°	234°	232°-235°
Venus	256½°-265½°	260°	260°	262°-262°
Mercury	130½°-139½°	132°	132°	132°-133°

Table V

Longitudes of the nodes of the orbits of planets

Planets	Āryabhaṭīya	Khaṇḍa- khādyaka siddhānta	Varāha Sūrya- siddhānta	Modern Sūrya- siddhānta
Saturn	40°	40°	Not stated	Have to be
Jupiter	20°	20°	in the	calculated
Mars	80°	80°	Text	from the
Venus	60°	60°		data of the
Mercury	100°	100°		text

Table VI

Orbital inclinations (geocentric) to the ecliptic

Planets	Āryabhaṭīya	Khaṇḍa- khādyaka	Varāha Sūrya- siddhānta	Modern Sūrya- siddhānta
Mars	90'	90'	10'	90'
Mercury	120'	120'	135'	120'
Jupiter	60'	60'	101'	60'
Venus	120'	120'	101'	120'
Saturn	120'	120'	135'	100'

The *Mahabhāskariya* of Bhāskara I (522 A. D.) contains a passage which corroborates the fact that Āryabhaṭa I was the author of both the *audayika* and the *ardharātri* systems of Indian Astronomy. According to Pṛthudakasvāmin, whose

commentary on the *Brāhmasphuṭasiddhānta* we have the privilege of presenting to the public, it is clear that in certain respects Bhāskara and others may be wrong but the Āryabhāṭa's authenticity cannot be questioned. Pṛthūdakasvāmin while commenting on the *Brāhmasphuṭasiddhānta*, XI. 26 writes:

Such a mistake may have been made by Bhāskara and others; they have not understood his (Āryabhāṭa's) intention.

The passage in the *Mahābhāskariya* giving constants of the *ardharātri* system runs as follows (we are giving the translation from Kripa Shankar Shukla's edition on the *Mahābhāskariya*) :

The astronomical processes which have been set forth above come under the sunrise day - reckoning (*audayika* system). In the midnight day-reckoning (*ardharātri* system) too, all this is found to occur: the difference that exists is being stated (below).¹

The next fourteen stanzas relate to the midnight day-reckoning of Āryabhāṭa I.

- (i) Civil days and omitted lunar days in a *yuga* and revolution numbers of Mercury and Jupiter are thus given :

(To get the corresponding elements of the midnight day-reckoning) add 300 to the number of civil days (in a *yuga*) and subtract the same (number) from the number of omitted lunar days (in a *yuga*); and from the revolution numbers of (the *siḡhrocca* of) Mercury and Jupiter subtract 20 and 4 respectively.²

Thus according to the midnight day-reckoning, we get

civil days in a <i>yuga</i>	=	1,577,917,800
omitted lunar days in a <i>yuga</i>	=	25,082,280
revolution number of the <i>siḡhrocca</i> of		
Mercury	=	17,937,000
revolution number of Jupiter	=	364,220

1. निबन्धः कर्मणां प्रोक्तो योऽसावौदयिको विधिः ।

अर्धरात्रे त्वयं सर्वो यो विशेषः स कथ्यते ॥

—MBh. VII. 21

2. त्रिशती भूदिने क्षेप्या ह यवमेभ्यो विशेष्यते ।

॥ गुर्वोर्मेगयेभ्योऽपि त्रिशतिस्रच ततोऽन्वयः ॥

—MBh. VII. 22

- (ii) Diameters of the Earth, the Sun and the Moon are thus given :

(In the midnight day-reckoning) the diameter of the Earth is (stated to be) 1,600 *yojanas*; of the Sun 6,480 (*yojanas*) and of the Moon, 480 (*yojanas*)¹.

- (iii) Mean distances of the Sun and the Moon are as follows :

The (mean) distance of the Sun is stated to be 689,358 (*yojanas*), and of the Moon 51,566 (*yojanas*).²

- (iv) Longitudes of the apogees of the planets are as follows: 160, 80, 240, 110, and 220 are in degrees the longitudes of the apogees of Jupiter, Venus, Saturn, Mars and Mercury respectively.³

- (v) *Manda* and *Śighra* epicycles of the planets are as follows :

The *Manda* epicycles (of the same planets) are 32, 14, 60, 70, and 28 (degrees) respectively; and the *Śighra* epicycles are 72, 260, 40, 234, and 132 (degrees) respectively. The Sun's apogee and epicycle are the same as those of Venus (i. e. 80° and 14° respectively).

The Moon's epicycle in the midnight day-reckoning is stated to be 31 (degrees).⁴

- (vi) The positions of the so called *manda* and *śighra pātas* of the planets are given below:

(The following directions for) the degrees of the (*manda* and *śighra*) *pātas* of the planets as devised

1. अष्टिश्शतगुणा व्यासो योजनानां भुवो रवेः ।
खाद्यव्यङ्गानि शीतांशोः शून्यवस्वव्ययस्तथा ॥ —23
2. वसिन्दित्रय गुणच्छिद्रवस्वङ्गानि विभावसोः ।
अङ्गाङ्गोन्वेक भूतानि चन्द्रकर्णः प्रकीर्तितः ॥ —24
3. अष्टिरष्टौ जिनारुद्रा विंशतिर्द्वयधिकाः क्रमात् ।
दशान्ता गुरुशुक्राकिं सौमन्वांशाः स्वमन्दजाः ॥ —25
4. मन्दवृत्तानि द्वाविंशन्मनवः षष्टिरेव च ।
खाद्ययो वसुदत्ताः स्युः शीघ्रवृत्तान्यथ क्रमात् ॥ —26
- द्वयद्वयः खाङ्गनेत्राणि खाङ्गयोऽव्ययनिदक्षकाः ।
द्वयन्नीन्दवो रवेर्मन्दं शुक्रवद् वृत्तमेव च ॥ —27
- एकविंशतपामतु रर्वरात्रे विधीयते ।

(under the midnight day-reckoning) should be noted carefully by learned scholars :

Add 180° to the longitudes of the *mandoccas* (apogees) and *sighroccas* of Mercury and Venus, and subtract 3 signs from the *mandoccas* (apogees) and *sighroccas* of the remaining planets. Then are obtained the longitudes of the *manda* and *sighra pātas* of the planets. (Also) add 2 degrees to the longitudes of the *manda pātas* and *sighroccas* of Venus, Saturn and Jupiter, and $1\frac{1}{2}$ degrees to those of Mars and Mercury. (It should be noted that) the *sighra pātas* have been stated for all the planets excepting Mercury. (Mercury does not have a *sighra pāta*).¹

That is to say, the longitudes of the *manda pātas* of Mars, Mercury, Jupiter, Venus, and Saturn are 21.5, 41.5, 72, 262 and 152 degrees respectively; and the longitudes of the *sighra pātas* of Mars, Jupiter, Venus and Saturn are (*sighrocca*— 88.5°), (*sighrocca*— 88°), (*sighrocca*+ 182°) and (*sighrocca*— 88°) respectively.

(vii) A rule for finding the celestial latitude of a planet is as follows :

(From the longitude of a planet severally) subtract the longitudes of its (*manda* and *sighra*) *pātas* and therefrom calculate (as usual) the corresponding celestial latitude of that planet. Add them or take their difference according as they are of like or unlike directions. Then is obtained the true celestial latitude of that particular planet. The true celestial latitude of any other planet is also obtained in the same way. The remaining (astronomical) determinations are the same as stated before. This all is in brief the difference of the other *tantra* (embodying the midnight day-reckon-

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- | | |
|--|-----|
| 1. पातभागाश्च विज्ञेयाः परिहृतैः परिकल्पिताः ॥ | —28 |
| मन्द शीघ्रोच्चयोः क्षेप्यं चक्रार्धं बुधशुक्रयोः । | |
| राशित्रयं तु रोषाणां पात्यते पातसिद्धये ॥ | —29 |
| शुक्रार्कदेव पूज्यानां भागौ द्रावेव संयुतौ । | |
| मन्दपाताच्च शीघ्रोच्चात् साधौ शस्तु कुजहयोः ॥ | —30 |
| विबुधानां च सर्वेषां शीघ्रपाताः प्रकीर्तिताः । | |

ing of Āryabhata I).¹

(viii) A rule for finding the longitude of the true mean planet according to midnight-day reckoning is as follows :

Apply half the *Sighraphala* and (then) half the *mandaphala* to the longitude of the planet's own *mandocca* (reversely).

From the resulting longitude of the planet's *mandocca* calculate the (*mandaphala* and apply it to mean longitude of the planet : the resulting longitude of planet is stated to be) the true-mean longitude of the planet. This is stated to be another difference (of the midnight day-reckoning) ²

(ix) Length of the circle of the sky and derivation of the lengths of the orbits of the planets are given as follows :

Multiply the revolutions of the Moon (in a *yuga*) by 3, 240,000 and then discard the zero in the unit's place : (this is the length of the circle of the sky in terms of *yojanas*). (Severally) divide that by the revolutions of the planets (in a *yuga*): thus are obtained the lengths of the orbits of the respective planets in terms of *yojanas*.³

From these stanzas (from 20-35), it is evident that one *yojana* of the sunrise day-reckoning is one and a half times that of the midnight day-reckoning.

Now from stanza 22, it appears that 300 is to be added to the number of civil days in a *Mahayuga*. According to the *Āryabhatīya*, the number of civil days in this cycle is 1,577,917,500, which increased by 300, becomes 1,577,917,800, the number of

1. शोधयित्वा क्रमात् पातान् विज्ञेयान् प्रसाधयेत् । —31
योगविश्लेषनिष्पत्तिकानेकस्वदिवशात् ।
विज्ञेयः स स्फुटो ज्ञेयो ग्रहस्यैकस्य कीर्तितः ॥ —32
अन्यस्याप्येवमेव स्याच्छेषः प्रागुक्त कल्पनाः ।
एतत्सर्वं समासेन तन्वात्तरमुदाहृतम् ॥ —MBh. VII. 31 (ii)-33
2. शीघ्रमन्दोच्चचापार्श्वसंस्कृता ह स्वीयमन्दतः ।
स्फुटमध्यग्रहाः स वै विशेषः परिकीर्तितः ॥ —MBh. VII. 34
3. वेदाखिरामगुणितान्य युताहृतानि ।
चन्द्रस्य शून्यरहितान्यथ मण्डलानि ॥
रः स्वैहृतानि भगणैः क्रमशो ग्रहाणां ।
कक्ष्या भवन्ति खलु योजमानदृष्ट्या ॥ —MBh. VII. 35

civil days in a *Mahāyuga* according to Brahmagupta as referred to in the *Khaṇḍakhādya*.

Again, the same stanza tells us to subtract 20 and 4 respectively from the revolutions of Mercury and Jupiter, and we arrive at the figures 17,937,000 and 364, 220, which are the revolutions of Mercury and Jupiter in a *Mahāyuga* according to Brahmagupta as given in the *Khaṇḍakhādya*.

Again we can compare the figures for the diameters of the Earth, the Sun and the Moon given in the *Mahābhāskariya*, in the present day *Sūrya-siddhānta* and the *Āryabhaṭiya*.

Diameter of	<i>Mahābhāskariya</i>	Modern, <i>Sūrya-siddhānta</i>	<i>Āryabhaṭiya</i>
Earth	1,600 yojanas	1,600 yojanas	1,050 yojanas
Sun	6,480	6,500	4,410
Moon	480	480	315

Then in stanza 24, we are given the distances of the Sun and the Moon as 689, 358 and 51, 566 yojanas respectively. The same figures are worked out by Lalla according to the *Āryabhaṭiya* and quoted in the *Śiṣyadharmyādhikā* (IV.3.4) and they come to be 459,585 and 34,377.

The stanza 25 states the longitudes of the aphelia of planets these figures tally with the corresponding figures given by Brahmagupta in the *Khaṇḍakhādya* :

Longitude of aphelion of Jupiter 160°, of Venus 80°, of Saturn 240°, of Mars 110° and of Mercury 220°.

Similarly the stanza 26 gives the peripheries of planets' epicycle of apsis, which also is in concordance with the values given by Brahmagupta :

Periphery of epicycle of apsis of Jupiter 32°, of Venus 14°, of Saturn 60°, of Mars 70° and of Mercury 28°.

In the stanza 27 of the *Mahābhāskariya*, we have the dimensions of the epicycles of conjunction for planets; these figures are also the same as given by Brahmagupta :

Epicycles of conjunction for Jupiter 72°, for Venus 260°, for Saturn 40°, for Mars 234° and for Mercury 132°.

In the stanza 28, we have the Sun's epicycle having a periphery of 14° and the Moon's epicycle 31°; the longitudes of

the nodes of the planets to be the same as in the *Āryabhaṭīya*. All these are the same as given by Brahmagupta in the *Khaṇḍakhādyaka*.

In the stanza 33 we have rules for finding the geocentric longitudes of planets which may be taken to be the same as in the *Khaṇḍakhādyaka*¹; compare these values with those in the *Sūryasiddhānta* of Varāhamihira in the *Pañcasiddhāntikā*, XVII. 6, but slight different from the *Āryabhaṭīya*.²

The last stanza of the *Mahābhāskariya* (35) gives the dimensions in *yojanas* of the orbits of planets ; these are the same as in the modern *Sūryasiddhānta*.

Thus we find a great semblance in the constants as given by the *Mahābhāskariya* of Bhāskara I, of the *Sūryasiddhānta* as given by the *Pañcasiddhāntikā* and understood by Varāhamihira, and also the constants as given by Brahmagupta in his treatises, specially the *Khaṇḍakhādyaka*. It must not be forgotten that the same Āryabhaṭa I who is the celebrated author of the *Āryabhaṭīya* is also the author of another treatise very often referred to as the *Tantra*.

I shall quote Prabodha Chandra Sengupta in connection with these similarities, and the great influence of Āryabhaṭa on Indian Astronomy. He writes in his Introduction to the *Khaṇḍakhādyaka* as follows :

We have shown that there is much resemblance in the constants between the *Sūryasiddhānta* of Varāha and the *Khaṇḍakhādyaka* and for the matter of that with the *Tantrāntara* of Āryabhaṭa I. In my papers "Āryabhaṭa and Āryabhaṭa's Lost Work", I have established the fact that the *Sūryasiddhānta* as it existed before the time of Varāha, was made more accurate by him by borrowing the constants from Āryabhaṭa's *ardharātri* system. That there was a *Sūryasiddhānta*

१. शीघ्रफलाद्धं मध्ये मन्दफलाद्धं च मन्दशीघ्रफले ।

सकले मध्ये स्पष्टः शीघ्रं मध्योनकं केन्द्रम् ॥

—KK. II. 18

२. मन्दोच्चाच्छीघ्रोच्चादर्थस्य धनं ग्रहेषु मन्देषु ।

मन्दोच्चात्स्फुट मध्याश्रीघ्रोच्चाच्च स्फुटा ज्ञेयाः ॥

शीघ्रोच्चादर्थोनं कर्तव्यमृणं धनं स्वमन्दोच्चे ।

स्फुटमध्यौ तु शृगुबुधौ सिद्धान्मन्दात्स्फुटौ भवतः ॥

—Arya. III. 23-24

before the time of Varāha, is seen from Section 6 of the Table on page xii given before. This point is made clear from another consideration, viz., the star table in the modern *Sūryasiddhānta*, which unmistakably points to the conclusion that the longitudes of some stars, e.g., Spica etc., correspond to a time much anterior to that of Āryabhaṭa I. The great fame of Āryabhaṭa I induced Varāha, the first maker of a *neo-Sūryasiddhānta* to use the elements of Āryabhaṭa's *ardharātri* system to supplant the older materials in it. No wonder, therefore, that there is an opinion in favour of the hypothesis that Āryabhaṭa I was the author of the *Sūryasiddhānta*. If there were a shadow of truth in it, Varāha would have admitted it. Alberuni indeed says that the *Sūryasiddhānta* was composed by Lāṭa (Alberuni's India, translated by Sachau, Vol. I.p. 153). We now know that this Lāṭa or Lāṭadeva was one of the first pupils of Āryabhaṭa I. He was the expounder of the Romaka and Pāuliśa *Siddhāntas* as we learn from Varāhamihira's *Pañcasiddhāntikā*, (I.3). As Alberuni's statement is not corroborated by Varāha, we are not inclined to take it as correct. None of the earlier writers suggest that the *Sūryasiddhānta* was in any way modified or changed by Āryabhaṭa I.

It has now been established beyond doubt that the same Āryabhaṭa was the author of the *Aryabhaṭīya* and another *Tantra* which is now lost. There is reason in support of hypothesis that this *Tantra* itself was the first work of Āryabhaṭa I and that the *Aryabhaṭīya* was the second work from the order in which Varāha mentions them in the Stanza quoted earlier. If this hypothesis be true, the stanza in the *Aryabhaṭīya*¹, which was translated by me as :

"Now when sixty times sixty years and three quarter *yugas* also have elapsed, twenty increased by three years have elapsed since my birth."

1. षष्ट्यब्दानां षष्टिर्यदा व्यतीतास्त्रयश्च युगपादाः ।

व्यधिका विंशतिरब्दास्तदेह मम जन्मनोऽतीताः ॥

—*Ārya. III. 10.*

should now be translated thus :

"In this *Mahāyuga* when sixty times sixty years and three quarter yugas also had passed, twenty increased by three years had elapsed since my birth."

Now Bhāskara I the author of the *Mahābhāskariya* and the *Lagubhāskariya*, wrote a commentary on the *Āryabhaṭiṭya*. The author commenting on this stanza observes that :

"Or this was addressed by Āryabhaṭa when expounding the science to Pāṇḍuraṅgasvāmin, Lāṭadeva Nīḥśanku and other pupils."¹

This direct pupil of Āryabhaṭa I also says that this stanza does not show that the *Āryabhaṭiṭya* was composed when Āryabhaṭa I was only 23 years old, but refers to the time when he probably began his career as a teacher of Astronomy.

Senagupta out of his discussion concludes that we are not justified in accepting that the *Āryabhaṭiṭya* was composed when Āryabhaṭa was only 23 years of age. This treatise as it exists in the present form must have been the composition of a mature age; it is a treatise highly finished in form; the date mentioned in this great work refers to a date when its author became a reputed *guru* or teacher.

Alberuni and Brahmagupta

Dr. E.C. Sachau in his translation of Alberuni's India (vol. II. p. 304) speaks of Brahmagupta in the following words :

Brahmagupta holds a remarkable place in the history of Eastern civilization. It was he who taught the Arabs astronomy before they became acquainted with Ptolemy; for the famous *Sindhind* of Arabian literature, frequently mentioned but not yet brought to light, is a translation of his *Brāhmasiddhānta*; and the only other book on Indian astronomy, called *Atarkand*, which they knew, was a translation of his *Khaṇḍakhādyaka*.

Brahmagupta, the celebrated author of the *Brāhmasphuṭa-siddhānta*, has another great work as we have said before to his credit which goes by the name *Khaṇḍakhādyaka*. This has

1. एतदेवाचार्य्यमदस्य शास्त्रव्याख्यान समये वा पाण्डुरङ्गस्वामिलाटदेवनिःशङ्कुप्रभृतिभ्यः प्रोवाच ।

already been said that perhaps to meet the popular demand, Brahmagupta in this treatise took upon himself the task of simplifying Āryabhata's *ardharātrika* system or the system of midnight day reckoning. Alberuni, the author of the *Indika* has made several references or quotations from the *Khaṇḍakhadyaka* proper and also its supplement, known as *Uttara-Khaṇḍakhadyaka*.

- (a) There is a reference to the accepted circumference of the Earth, as given in the *Khaṇḍakhadyaka* (Sachau's *Alberuni*, Vol. I, p. 312)

Multiply the difference in longitude (from Ujjayini) by the (mean) daily motion of a planet (in minutes) and divide by 4,800; apply the quotient taken as minutes negatively in places east of the meridian line of Ujjayini and positively in places lying west.¹

- (b) The rules for finding the *ahargana* as given in the *Khaṇḍakhadyaka* in I. 3-5 (Sachau's *Alberuni*, Vol. II, 46-47), to which Dr. Schram adds a valuable annotation, the constants being taken from the later Pauliṣa Tantra as known to Bhāṭṭotpala. This Pauliṣa astronomy is derived from Āryabhata I's *ardharātrika* system.²

- (c) A quotation from the *Uttara Khaṇḍakhadyaka* (Sachau's *Alberuni*, Vol. II, pp. 84-86) which Sengupta has given in his translation, Chapter X, pp. 148-152.

- (d) A quotation also probably from the *Uttara Khaṇḍakhadyaka* (Sachau's *Alberuni*, Vol. II, p. 87). These stanzas are found in the *Brāhmasphuṭasiddhānta*, XIV, 47-52, also quoted by Bhāṭṭotpala as occurring in the *Brahma Siddhānta* in his commentary on the *Bṛhat-Samhitā*, IV, 7. The manuscripts which Sengupta used did not show them as occurring in the *Uttara Khaṇḍakhadyaka*. These relate to the dimensions of the *nakṣatras* as seen, as distinguished from the same as calculated.

1. उज्जयिनी-याम्योत्तर-रेखायाः प्रागृणं धनं पश्चात् ।

देशान्तर भुक्तिवधात् ख खाष्टवेदैः कलायाप्तम् ॥

2. - *KK*, Pt. B. Misra's edition, p. 145.

- (e) Two quotations from the *Uttara Khaṇḍakhādyaka* relating to the celestial co-ordinates of Canopus and Sirius (Sachau's Alberuni, Vol. II, p. 91). Present manuscripts do not show these stanzas, which are probably the same as stanzas 35-36 and 40 of Chapter X of the *Brāhmasphuṭasiddhānta*.
- (f) Two quotations from the *Khaṇḍakhādyaka* proper as alleged by Alberuni (Sachau's Alberuni, Vol. II, p. 116). According to Āmarāja, the first is a couple of stanzas of which the author is Bhaṭṭotpala and not Brahmagupta. The second quotation cannot be traced. These relate to finding the possibility of an eclipse whether of the Sun or of the Moon.
- (g) Two quotations from the *Khaṇḍakhādyaka* proper as asserted by Alberuni (Sachau's Alberuni, Vol. II, p. 119). These relate to finding the Lords of the year and of the month. According to Āmarāja the rules in question were given by Bhaṭṭotpala and not by Brahmagupta. Pṛthūdaka in his commentary on the first chapter at its concluding portion says ;

"In this work the *Khaṇḍakhādyaka*, the teacher (Brahmagupta) has not given the rules for finding the Lords of the year and the month¹."

1. अथाऽत्र खण्डखाद्यके वर्षाधिपमासाधिपानयनमाचार्येण नाभिहितम् ।

—: 0 :—

Reference

- P.C. Sengupta : *The Khaṇḍakhādyaka*, 1934.
 K.S. Shukla : *Mahābhāskariya*, 1960.
 K.S. Shukla : *Sūrya-Siddhānta*, 1957.

Brahmagupta's Originality in the *Khaṇḍakhādyaka*

Sengupta in his Introduction to the Commentary of the *Khaṇḍakhādyaka* has discussed this point. We shall reproduce here some of the points mentioned by him.

Brahmagupta's *Khaṇḍakhādyaka*

(i) Brahmagupta does not accept the system of Āryabhaṭa but has simplified it in the *Khaṇḍakhādyaka* proper ; and here he has given the system which he thinks to be correct.

Uttar Khaṇḍa Khādyaka

(ii) In the *Uttara-Khaṇḍakhādyaka*, he has further corrected some of his results, given earlier in the *Khaṇḍakhādyaka* proper. In the proper *Khaṇḍakhādyaka*, Brahmagupta assigns to the longitude of the Sun's apogee the value 80° , whereas in the *Uttara* text he corrects it to 77° (UKK. 4) :

As the process of finding the apparent places of planets as given by Āryabhaṭa does not make them agree with observation, I shall, therefore, speak of this process. Of the Sun the apogee is at two signs and seventeen degrees ($2 \text{ signs } 17^\circ = 60 \text{ plus } 17 \text{ degrees} = 77^\circ$).¹

Compare this with the value given in the *Khaṇḍakhādyaka* proper (I.13)² :

The longitude of the Sun's apogee is 80° [KK.I,13] (The Sun's apogee is 80° or two signs plus 20 degrees) *inocco* means

1. न स्फुटमार्थ्यभटोक्तं स्पष्टीकरणं यतस्ततो वक्ष्ये ।
भानुमती मन्दोच्चं राशिद्वयमंशकाश्च सप्तदश ॥
2. भागाशीतिरिनोच्चं राशिनः पादोनकृत शरद्वलोनाद् ।
भगणादि द्वित्रिरदैर्बसुनव यम नव गुणैः सकलम् ॥

UKK. IX 4

KK. I, 13

mandocca of the Sun). The value given in the *Pañcasiddhāntikā*, IX.7-8) is also the same.

Let us compare it with the present value. According to the astronomical constants as given in the *Conn. des Temps.*, the longitude of the Sun's apogee in 499 A.D. (i.e. 1,400 years before 1900 A.D.) was

—77° 19'19.44" according to *Conn. des Temps'*
equation.

—76° 40'37.22" according to Newcomb's equation.

The mean of these two values is very nearly 77° as given by Brahmagupta in the *Uttara* text. Thus the value given by Brahmagupta is more correct than the value given by Āryabhaṭa. The *Āryabhaṭiya* gives the value 78° which is less correct.

Brahmagupta more correct than Āryabhaṭa

(iii) Brahmagupta detected that Āryabhaṭa had made the Moon's apogee quicker and nodes slower, than they really are. In both the cases, Brahmagupta made rather an over-correction. We shall give the extract from *Uttara-Khaṇḍakhadyaka* in this connection :

Multiply the *ahargana* by 110, increase the product by 511 and divide by 30, 31; subtract the result taken as revolutions, etc., from the mean Moon; the final result is the Moon's apogee.¹

Evidently Brahmagupta assumes that the anomalistic month=3031/110 days. This convergent to the anomalistic month was known to the author of the *Vasiṣṭha Siddhānta* as summarised in the *Pañcasiddhāntikā*² (II-2-6).

According to Brahmagupta, the length of the anomalistic month

$$\begin{aligned}
 &= \frac{1582236450000 - 4320000000}{57753300000 - 488105858} \text{ days. (} B_r S_p S_i \text{ I.15,16,18,} \\
 &\quad \text{and 20)} \\
 &= 27.55454641 \text{ days which is for 1900 A. D.} \\
 &= 27.5545502 \text{ days according to Radau.} \\
 &= 27.554602 \text{ according to the } \textit{Āryabhaṭiya}.
 \end{aligned}$$

1. घुग्ण्यात् खं रुद्रं गुणित्वाद् भवशरयुक्ताच्छशिनिखाग्निं हृतात् ।
भग्यादि फलं शोध्यन्धसचन्द्राच्छशाङ्कोच्चम् ॥

Here also Brahmagupta is more accurate.

Again, the length of the sidereal period of the Moon's apogee

$$= \frac{1577918450000}{488105858} \text{ days}$$

$$= 3232.732048 \text{ days.}$$

Āryabhaṭa's value of the same is 3231.987844 days, and the modern value is 3232.3754 days. Hence Brahmagupta's result is by 0.3566 of a day out, while Āryabhaṭa's is by 0.3876 of a day in.

Further in the *Uttara-Khaṇḍakhādyaka* (IX.10) we have : Deduct 354½ from the *ahargana*, divide the remainder by 6792 ; subtract the quotient that is obtained in revolutions etc. from the circle : the result is the longitude of the ascending node.¹ (IX.10)

Here Brahmagupta gives the approximate period of the sidereal revolution of the Moon's node to be=6792 days. This according to his *Brāhmasphuṭasiddhānta*= $\frac{1577916450000}{232311168}$ days

= 6792.25396 days, which according to Lockyer would be 6793.39108 days and according to the *Khaṇḍakhādyaka* proper is 6794.75083 days. Hence Brahmagupta's attempt to correction makes the node quicker than it actually is.

Brahmagupta corrects Mars's Aphelion Point

(iv) Again Brahmagupta states that the longitude of Mars's aphelion should be increased by 17° and that of Jupiter by 10°. Evidently here too, Brahmagupta is more correct than Āryabhaṭa. The passage in the *Uttara Khaṇḍakhādyaka* is as follows in this connection :

Of Mars the apogee (the aphelion point) is to be increased by 17°, that of Jupiter by 10° ; from the *siḡhra* of Venus 74' are to be subtracted ; Saturn's equation of apsis should be decreased by its one-fifth ; the *siḡhra* equation of Mercury should be increased by

1. सार्द्धं कृतेषु गुणोनादहर्गणाद् द्विनवमुनि-रसैर्भक्तत्वात् ।

यन्मण्डलादि लब्धं चक्रात् संशोध्य तत् पातः ॥

one-sixteenth.¹

This stanza says that in 499 A.D., Mars's aphelion point had a longitude of 127° ; of Jupiter the longitude of the aphelion was 170° . (*KK.II. 6*²)

According to Newcomb's rule, the longitude of the aphelion point of Mars in 499 A. D. works out to have been $= 128^{\circ}28'12''$. According to the *Conn. des. Temps'* rule, the same was $128^{\circ}27'51''$. Hence Brahmagupta's determination of Mars's aphelion is correct within $1^{\circ}30'$ and is therefore, quite satisfactory. According to the *Khaṇḍakhādyaka* proper it was 110° , and according to the *Āryabhaṭīya* 118° .

Of planets, beginning with Mars, the degrees of longitude of the apogees are respectively 11, 22, 16, 8 and 24, each multiplied by 10. (*KK.II. 6*)

Thus the longitudes of apogees of Mars $= 110$ (3 signs 20°); of Mercury $= 220$ (7 signs 10°); of Jupiter $= 160$ (5 signs 10°); of Venus $= 80$ (2 signs 20°) and of Saturn $= 240$ (8 signs). Compare these values with those given in the *Pañcasiddhāntikā* XVII. 2 (the *Sūrya-siddhānta*).

Again according to this stanza Jupiter's aphelion had a longitude of 170° in 499 A.D.

According to *Conn. des. Temps'* rule the same was $170^{\circ}25'$. Thus here too, Brahmagupta is very accurate. According to the *Khaṇḍakhādyaka* proper, Jupiter's aphelion had a longitude of 160° (*KK. II.6*) and according to the *Āryabhaṭīya*, the value was 180° .

Brahmagupta First to Use Second Differences

All these illustrations reproduced here very well establish the point that the great Indian astronomers from Āryabhaṭa I to Brahmagupta were aware of the methods of separating the two distinct planetary inequalities, viz., that of the apsis and of conjunction in the cases of the five 'star' planets (*PSi. Introduction Lii*). In the *Khaṇḍakhādyaka*, Brahmagupta having given the "sines" and the equations of the Sun and the Moon

1. सप्तदशारौरधिकं भौमस्योच्चं गुरोर्दोशभिरंशैः ।

सितश्रीध्रात् कृतमुनयो लिप्ताः शोध्याः शनैः फलं मान्यम् ॥

पञ्चांशोनं शैव्यं षोडशमासाधिकं बुधस्य फलम् ॥

2. मन्दांशा दशगुणिता रुद्रा द्वियमाश्च षोडशाष्टजिनाः ।

—*UKK. IX. 11*

—*KK. II. 6*

at the interval of 15° of arc of the mean anomaly, in the *Uttara Khaṇḍakhādyaka* teaches, for the first time in the history of mathematics, the improved rules for interpolation by using the *second difference*. This very important feature I am reproducing here from the translation by Senagupta of the verse ¹ (UKK. 8):

Multiply the residual arc left after division by 900' (i.e. by 15°), by half the difference of the tabular difference passed over and that to be passed over and divide by 900' (i. e. 15°): by the result increase or decrease, as the case may be, half the sum of the same two tabular differences; the result which, whether less or greater than the tabular difference to be passed, is the true tabular difference to be passed over. (UKK. 8)

The rule given here applies to the case of all functions hitherto considered in the *Khaṇḍakhādyaka*, which are tabulated at the difference of 15° of arc of the argument. They are:

- (i) the tabular differences of the Sun's equation,
- (ii) the tabular differences of the Moon's equation.
- (iii) the tabular differences of the 'sines'.

Senagupta has illustrated the rule by an example belonging to the table of sines.

Illustration—"To find the 'sine' of 57° .

Brahmagupta's table of sines in the *Khaṇḍakhādyaka* is as follows:

Thirty increased severally by nine, six and one; twenty-four, fifteen and five, are the tabular differences of sines at intervals of half-a-sign. For any arc, the 'sine' is the sum of the parts passed over, increased by the proportional part of the tabular difference to be passed over.² (KK.I.30; also III.6)

1. गतभोग्य खण्डकान्तरदलविकलवधात् शतैर्नवभिराज्या ।
तदशुतिदलं युतोर्न भोग्यादूनाधिकं भोग्यम् ॥

—UKK. IX. 8

2. त्रिंशत् सनवरसेन्दुजिन (तिथि) विषयागृह्णाद् चापानां ।
अर्द्धज्या खण्डानि ज्या भुक्तैर्व्यं सभोग्यफलम् ॥

—KK. I. 30; also III. 6

This can be shown in the tabular form thus :

Arc	'Sine'	Tabular difference	Second difference
0°	0		
15°	39	39	
30°	75	36	—3
45°	106	31	—5
60°	130	24	—7
75°	145	15	—9
90°	150	5	—10

Now $57^\circ = 3420 \text{ minutes} = 900' \times 3 + 720'$. Thus three of the tabular differences are considered as passed over ; the last one being 31 and the one to be passed over is 24.

The true tabular difference by the rule, for arc 57° ,

$$= \frac{31+24}{2} - \frac{720}{900} \times \frac{31-24}{2}$$

Hence the 'sine' of 57°

$$= 39 + 36 + 31 + \frac{720}{900} \left[\frac{31+24}{2} - \frac{720}{900} \times \frac{31-24}{2} \right] \\ = 125.76$$

As worked out from the logarithm tables the same comes out to be 125.80.

Again 'sine' of 57° from Brahmagupta's formula

$$= 106 + \frac{720}{900} \times 24 + \frac{31-24}{2} \times \frac{720}{900} - \left[\frac{720}{900} \right] \times \frac{31-24}{2} \\ = 106 + \frac{720}{900} \times 24 + \frac{720}{900} \left[\frac{720}{900} - 1 \right] \times \frac{24-31}{2}$$

This in fact is the modern form the interpolation equation up to the term containing the second difference. Brahmagupta thus takes a decidedly improved step here and is undoubtedly the first man in the history of mathematics who has done this. One should also remember that in the case where the function is not tabulated at a constant interval, Brahmagupta's rule is remarkable.

Brahmagupta First to Introduce Sine Rule in Indian Plane Trigonometry

In this connection, we shall reproduce the following verse from the *Khandakhadyaka* :

Multiply the 'sine' of the (*Śighra*) anomaly by the 'sine' of the maximum *Śighra* equation and divide by the 'sine' of the corresponding *Śighra* equation, the result is the '*Śighra* hypotenuse' when the (*Śighra*) anomaly is half a circle, this *śighra* hypotenuse is equal to the radius diminished by the 'sine' of the maximum equation ; when the anomaly is equal to the whole circle, the same is equal to the radius increased by the same 'sine' of the maximum equation.¹

Let S, E and P be the positions of the Sun, the Earth and the

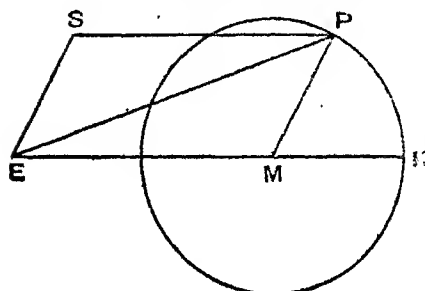


Fig. 4

planet, say Mars, respectively. Complete the parallelogram SEMP ; with M as centre and MP as radius, describe a circle. This circle is the epicycle of conjunction of Mars. Produce EM to cut this circle at K. The $\angle PMK = \angle S'SP$ (the point S' is on ES produced), the angle

gained by the Earth over Mars since the preceding conjunction. The $\angle PMK$ is called the *śighra* anomaly or anomaly of conjunction. We take $EM=360$, and $MP=234$. The $\angle PEM$, which is equal to $\angle PES$, the annual parallax of Mars, is called the *śighra* equation. The $\angle MPE$ is equal to the $\angle SEP$, the elongation. The $\angle PMK$ is given, and PM and ME are also given. Hence in the triangle MPE, we have

$$\begin{aligned} \tan \frac{1}{2}(P-E) &= \frac{EM-MP}{EM+MP} \tan \frac{1}{2} PMK \\ &= \frac{126}{594} \tan \frac{1}{2} PMK \end{aligned}$$

$$\therefore L \tan \frac{1}{2}(P-E) = \log \left[\frac{126}{594} \right] + L \tan \frac{1}{2} PMK$$

We have also $\frac{1}{2}(P+E) = \frac{1}{2} \angle PMK$

1. केन्द्रज्याऽन्त्यकलज्या गुणिता फलजीवया हताकर्णः ।

त्रिज्यान्व फलज्योना चक्राद्धे संयुता चक्रे ॥

$$\text{Now } \log \left[\frac{126}{594} \right] = 1.3265841.$$

The values of the $\angle PMK$ and the $\angle PEM$ and Brahmagupta's values as given in the verse¹ are presented below in a tabular form :

$\angle PMK =$	28°	60°	90°	121°	135°	148°	164°	173°
$\angle PEM =$	10°58'	23°1'	33°1'	39°56'	40°23'	37°31'	25°32'	12°35'
Brahmagupta's $\angle PEM =$	11°	23°	33°	40°	40°30'	37°30'	25°30'	12°30'

It will be seen that Brahmagupta gives the values of the equation within 1/8th of a degree. It seems inexplicable why such discrepancies should remain in Brahmagupta's calculations. It is probable that he wanted to state his equations to the nearest half a degree.

Now we shall take up the *Sighra* equations of Mars, and then revert to the Sine Rule. We have in the *Khanḍakhādya* :

Mars, by the degrees of *Sighra* anomaly (i.e. anomaly of conjunction) of 28 getting at the corresponding equation of 11° rises (heliacally) in the east ; by the next 32° gets 12° more of the equation ; by the next 30°, 10° more ; by the next 31°, 7°, more ; by next 14°, half a degree ; these are positive ; by the next 13°, negative 3° ; by the next 16° ; negative 12° after this he is retrograde ; by the next 9°, negative 13° ; by the next 7°, negative 12½°. After this the parts of the equations occur in the reverse order¹.

On the basis of this we have the following table of the *Sighra* equations for Mars ;

Degrees of anomaly of conjunction	Equation of conjunction	Phenomena
0°	0°	Motion direct.
28°	+11°	Rises in the east.

1. भौमोऽष्टयमै रुद्रान् सुक्त्वा पूर्वोदितोरदैरकां ।
ख् ऐदैशरूपगुणैः सप्तशशा मनुभिरर्द्धां शान् ॥
धनम् मग्नि शशाङ्क स्त्रीनिष्ठया भास्करान्तो वक्त्री ।
नवमित् योदशानगैर्दशसाक्षांन् विलोमोऽतः ॥

Degrees of anomaly of conjunction	Equation of conjunction	Phenomena
60°	11+12=+23°	
90°	23+10=+33°	
121°	33+ 7=+40°	
135°	40+ ½=+40°30'	
148°	40°30'—3°=+37° 30'	
164°	37°30'—12°=+25°30'	Retrograde motion begins.
173°	25°30'—13°=+12°30'	
180°	12°30'—12°30'=0°0'	
187°	—12°30'	
196°	—25°30'	Direct motion begins.
212°	—37°30'	
225°	—40°30'	
239°	—40°	
270°	—33°	
300°	—23°	
332°	—11°	Sets in the west.
360°	0°	

Now we come back to our discussion on the verse VI.1.

The *Śighra* hypotenuse spoken of here is EP, when SP or EM is taken to be R; when $\angle PEM$ is a maximum, PM is its 'sine'.

It would be seen from the figure that

$$EP = \frac{R \sin PMK \times PM}{R \sin PEM}$$

This may again be written as

$$\frac{EP}{\sin PMK} = \frac{PM}{\sin PEM}$$

This is equivalent to the sine rule for a triangle in plane trigonometry. Brahmagupta is here seen to be the first person to give it in Indian mathematics. This expression reminds us of the famous relationship in respect to triangle ABC :

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

**Brahmagupta corrects
Dimensions of the Epicycle of Apsis**

Brahmagupta corrects the dimensions of the epicycles of apsis of the Sun and Moon by—1/42nd part and 1/48th parts respectively, The reference may be made to the following verse in the *Uttara Khanḍakhādyaka* :

The Sun's equations are to be made less by *dvikṛtāṁsonam* (1/42nd) and the Moon's equations, increased by *vasuvedabhāgayutam* (1/48th). Multiply the Sun's equation a planet's daily motion in minutes and divide by the number of minutes of a whole circle and this is called *Bhujāntara* correction and applied in the same way to the planet as the equation is applied to the Sun.¹

The Sun's epicycle of apsis has the dimension 14° in the *Khanḍakhādyaka* proper. With the correction introduced here, the value becomes $14^\circ \left[1 - \frac{1}{42} \right] = 13^\circ 40'$.

The correction to the Moon's equations would make the epicycle's dimension changed from 31° to $31^\circ \left[1 + \frac{1}{48} \right] = 31^\circ 38' 45''$.

Prthudaka's commentary further corrects it to $31^\circ \left(1 + \frac{1}{52} \right) = 31^\circ 35'$.

Brahmagupta's correction to Saturn's epicycle of apsis is—1/5th part and that to the *Śighra* epicycle of Mercury 1/16th part as seen in the verse :

Of Mars the apogee (the aphelion point) is to be increased by 17°, that of Jupiter by 10°; from the *Śighra* of Venus 74' are to be subtracted; Saturn's equation of apsis should be decreased by its one-fifth and the *Śighra* equation of Mercury should be increased by one-sixteenth.²

In the *Khanḍakhādyaka* proper (II.6), we have been given the longitudes of the apogee of planets: Mars 11°, Mercury 22°, Jupiter 160°, Venus 80° and Saturn 240°. Now with these corrections introduced in the *Uttara Khanḍakhādyaka* in the above

1. द्विकृतांशोनं रविफलमिन्दोर्वसुवेदभागयुतम् ।

अर्कफलमुक्तिधाताद् भगणकलाप्तं सृजान्तरं रविवत् ॥

UKK. IX. 9

2. सप्तदशांशैरधिकं भौमस्योच्चं युरोद् शमिरंशैः ।

सितशशिवात् कृतमुनयो लिप्ताः शोभ्याः शनैः फलं मान्यम् ।

पञ्चांशोनं शैब्यं षोडशभागाधिकं बुधस्य फलम् ॥

UKK. IX. 11

verse, the aphelion point of Mars in 499 A.D. had a longitude of $110 + 17 = 127^\circ$; of Jupiter $160 + 10 = 170^\circ$.

According to Newcomb's rule, the longitude of the aphelion point of Mars in 499 A.D. works out to have been $128^\circ 28' 12''$. The same according to *Conn. des Temps* rule would be $128^\circ 27' 51''$. Hence Brahmgupta's determination of Mars's aphelion is correct within $1^\circ 30'$, and may be, therefore, regarded as very satisfactory. According to the *Khaṇḍakhādyaka* proper this value was, as already said, 110° , while according to the *Āryabhaṭīya*, it was 118° .

The same may be said regarding Jupiter's aphelion. According to the *Khaṇḍakhādyaka* proper the value of its longitude is 160° , according to the *Āryabhaṭīya* it was 180° ; according to *Conn. des Temps*' rule, it would be in 499 A. D, $170^\circ 25'$, and the value given by Brahmagupta in the *Uttara Khaṇḍakhādyaka*, it is 170° .

We have thus shown by many illustrations the important corrections introduced by Brahmagupta in his *Khaṇḍakhādyaka* specially the *Uttara* part. Brahmagupta was highly original in his methods of calculations, accuracies and interpolations. He introduced new ideas in mathematics. He went much ahead Āryabhaṭa in many details. He so many times did not follow Āryabhaṭa in calculations. In the *Khaṇḍakhādyaka* proper, his treatment of parallax in the calculation of solar eclipses is different from that of Āryabhaṭa. The methods followed here are the same as propounded by him in the *Brāhmasphuṭasiddhānta*.¹

Senagupta is right when he says : As has already been remarked, these corrections and innovations in the *Uttara Khaṇḍakhādyaka* paved the way for the acceptance of his great work the *Brāhmasphuṭasiddhānta* as a standard work on astronomy by the western Indian school of astronomers. The directness of the treatment of topics, and the simplicity of calculations taught in the *Khaṇḍakhādyaka* made it very neat handbook for the beginner. These two works of Brahmagupta were perhaps the only astronomical works in circulations in western India when the Arabs conquered Sind early in the eighth century

1. On Parallax—

नाडी चतुष्कविधिना सर्वत्र समो यतस्ततः स्थूलः ।

मानार्थं कर्म महद् कृतमार्यभटेन लघुनि सति ॥

BrSpSi. XI. 33

(712 A.D.) and the new conquerers learnt Indian astronomy and mathematics from these works as has been observed by Sachau. Alberuni who came to India early in the 11th century of the Christian era, learnt Indian astronomy chiefly by studying the *Khaṇḍakhādyaka* and the *Bṛhat-Saṃhitā* of Varāhamihira, and both of them with the help of commentary of Bhaṭṭotpala.

—:C:—

Reference

P.C. Sengupta : *The Khaṇḍakhādyaka*, 1934.

CHAPTER VI

Indian Luni- Solar Astronomy

In this chapter, it is proposed to give an account of astronomical constants and the equations in Indian luni-solar astronomy and to present a comparative view of these quantities with the corresponding ones in Greek and modern Astronomy. This account has been reproduced from P. C. Sengupta's. Appendix I of the *Khaṇḍakhādya*. It has been shown that in many cases the Indian values of these constants are more accurate than the Greek values. and in Indian lunar astronomy the equations or inequalities discovered are the most startling.

Solar Astronomy

In solar astronomy the length of the year was determined by Āryabhata¹ from the heliacal risings of some bright star at the intervals of 365 and 366 days.

(1) The year according to the Āryabhaṭīya

$$= \frac{1577917500}{4320000} \text{ days} = 365.2586805 \text{ days,}$$

$$= 365 \text{ da. 6 hrs. 12 mins. 29.64 secs.}$$

(2) The same

$$= \frac{1577917800}{4320000} \text{ days} = 365.25875 \text{ days.}$$

$$= 365 \text{ da. 6 hrs. 12 mins. 36 secs., according to the}$$

Khaṇḍakhādya, the *Sūryasiddhānta* of Varāha
and the modern *Sūryasiddhānta*.

(3) It is

$$= \frac{1577916450}{4320000} \text{ days} = 365.2584375 \text{ days,}$$

$$= 365 \text{ da. 6 hrs. 12 mins. 9 secs., according to the}$$

1, P. C. Sengupta, "Āryabhata's Method of determining the Mean Motions of Planets," *Bulletin of the Calcutta Mathematical Society*. Vol. XII, No. 3.

Brahmasphuṭa Siddhānta of Brahmagupta.

Now the mean sidereal year

$$= 365 \text{ da. } 6 \text{ hrs. } 9 \text{ mins. } 9.3 \text{ secs. (Lockyer).}$$

The mean anomalistic year

$$= 365 \text{ da. } 6 \text{ hrs. } 13 \text{ mins. } 49.3 \text{ secs. (Lockyer).}$$

The mean tropical year

$$= 365 \text{ da. } 5 \text{ hrs. } 48 \text{ mins. } 46.054 \text{ secs. (Lockyer).}$$

Though we take that Indian year was designed to be the sidereal year, it approached most closely the anomalistic year; and its excess over the sidereal year was about 3 minutes. From this consideration it appears that the Indian astronomers were justified in taking the Sun's apogee to be fixed.

Against the error of +3 min. in the Indian sidereal year, we may point out that—

(1) The Hipparchus-Ptolemy tropical year

$$= 365 \text{ da. } 14' 48'' \text{ in sexagesimal units.}^1$$

$$= 365 \text{ da. } 5 \text{ hrs. } 55 \text{ min. } 12 \text{ secs., which has an error of about } +6 \text{ min.}$$

(2) Meton's sidereal year

$$= \left[365 + \frac{1}{4} + \frac{1}{76} \right] \text{ days}^2$$

$$= 365 \text{ da. } 6 \text{ hrs. } 18 \text{ min. } 57 \text{ secs., which has an error of } +9 \text{ min. } 48 \text{ secs. nearly.}$$

(3) The Babylonian sidereal-year was $4\frac{1}{2}$ min. too long.³

Thus the Indian value of it is closer to the true value.

Again in 150 A.D. the longitude of the Sun's apogee according to the *Conn. des Temps* was

$$= 101^\circ 13' 15''.17 - 6189''.03 \left[\frac{1900-150}{100} \right]$$

$$= 1''.63 \times \left[\frac{1900-150}{100} \right]^2$$

$$= 71^\circ 16' 26''.37$$

while Ptolemy states it to be $65^\circ 30'$ which was wrong by $-5^\circ 36' 27''$:

1. *Syntaxis*, Karl Manitius's edition, Vol. I, p. 146.

2. *Ibid.*, p. 145.

3. *Encyclopaedia Britannica*, History of Astronomy.

4. *Syntaxis*, Vol. I, p. 148. The Romaka Siddhānta of the *Pañca-siddhāntikā*, VIII. 2, indicates the Sun's apogee to be at longitude of 75° ; this was perhaps a correction made by Lāṭādeva to the Greek constant.

In 500 A. D (Āryabhaṭa's time) the longitude of the Sun's apogee by the same rule works out to be $=77^{\circ}19'19.44''$.

Āryabhaṭa states this to be 78° in the *Āryabhaṭīya*, Brahmagupta in the *Uttarādhyaīya* of the *Khaṇḍakhādya* states the same to be 77° , while the *Khaṇḍakhādya* gives it as $=80^{\circ}$. Hence the Indian findings of the longitude of the Sun's apogee were more accurate.

Again as to the Sun's equations of the centre we find that the *Āryabhaṭīya* states the periphery of the Sun's epicycle to be $13^{\circ}30'$. The *Khaṇḍakhādya* gives it as 14° ; while according to the Indian form, Ptolemy's value of the same is 15° . Hence according to these writers, the Sun's equations at 90° of the mean anomaly are :—

According to the *Āryabhaṭīya* $=2^{\circ} 8' 54''$.

„ „ *Khaṇḍakhādya* $=2^{\circ} 1' 40''$.

„ „ Brahmagupta $=2^{\circ} 7' 20''$.

„ „ Ptolemy $=2^{\circ} 23' 3''$.

The modern value $=1^{\circ} 55' 97''$.

Thus the Indian equations of the Sun are in general by more correct than the Greek ones. The Indian constants in solar astronomy are thus, generally, more accurate than the Greek ones. We now turn to the Indian Lunar astronomy.

Lunar Astronomy

Before discussing the constants in Indian lunar astronomy it is necessary to state something as to the time when the Moon was observed by our ancient astronomers and the astronomers from Āryabhaṭa I (499 A.D. to Pṛthūdaka Svāmī (864 A.D.). The months were reckoned from the first visibility of the crescent at the time of the *Mahābhārata* (1400 B. C.). We have a passage in the *Bhīṣmaparva* where Vyāsa speaks of the evil omens on the eve of the Kurukṣetra war thus—

चन्द्रसूर्यदुमौ ग्रस्तावेकामासौ त्रयोदशीम् ।

“That the Moon and the Sun have been both eclipsed on the 13th days of the light and dark halves of the same month.”

The eclipses could not take place on the 13th days of the month unless the months were reckoned from the first visibility of the crescent. This was the custom in Babylonia and it has still survived in the Mahomedan world. Even in the *Pañca siddhāntikā* of Varāhamihira (540 A. D.), there is a special

chapter on शशि-दर्शनम् or the first visibility of the crescent. It is thus clear that the practice was to observe the Moon when very near the Sun.

Again Āryabhaṭa says that 'खीन्दुयोगात् प्रसाधितश्चेन्दुः', "the Moon was determined from her conjunctions with the Sun." The Moon was observed by him at the time of solar eclipses, or at the time of the first visibility of the crescent.

Even up to the time of Pṛthudaka, the accuracy in lunar astronomy was chiefly aimed at the time of eclipses. Thus in his commentary on the *Khaṇḍakhādya* IV, he makes the following introductory remarks :—

"All knowledge relating to (luni-solar) astronomy is desired by the wise (or cultured) specially for knowing the right instants of opposition or conjunction ; these instants are, however, not visible to the eye. Of other things such as *tithis*, *nakṣatras* and *Karaṇas*, as the planets, the Sun and the Moon, are not clearly observed, their beginnings and ends are not visible. Men see the agreement between calculation and observation at the times of solar and lunar eclipses. Hence the word of the astronomers is esteemed amongst men even in respect to such things as *tithis*, etc."¹

Thus the chief aim of the ancient Indian astronomers was to calculate the eclipses accurately and the Moon was observed chiefly at lunar or solar eclipses, though the time for observation related also to the finding of the first visibility of the crescent. This latter phenomena did not perhaps lead them to directly observing the Moon's position at such times by using instruments.

Moon's Mean Motion

The practice of observing the Moon at the time of the eclipses alone led to the determination of the synodic month with the following results :—

$$\begin{aligned} & \text{(i) Mean synodic month according to the } \textit{\AA}ryabhaṭīya \\ &= \frac{1577917500}{57753336 - 4320000} \text{ days,} \\ &= 29.530582 \text{ days.} \end{aligned}$$

1. बाहुल्येन पर्व्वणानां सकलं ज्ञानमिष्यते शिष्टैः । तेषां च पर्व्वणां दर्शनं नास्ति । अन्येषामपि तिथिनिर्वाचनकरणानां तस्मात् तेषां शशिभास्करयोरव्यतिर्यक्त्वात् । शशिभास्कर-ग्रहणयोर्गङ्गादिदेवैर्लोकः पश्यति । तस्मात् तिथ्यादिष्वप्यर्थेषु देवैर्वाक्यं लोके आद्रियते ।

- (ii) The same according to the *Khaṇḍakhādya*
=29.5305874 days.
- (iii) The same according to the *Brahma-sphuṭa-siddhānta*
=29.530582 days.
- (iv) The same according to Ptolemy=29 da. 31' 50" 8" 20"
in sexagesimal units=29.5305927 days
- The modern value according to Newcomb and Radau
=29.5305881 days.

Hence the *Khaṇḍakhādya* mean length appears to be the closest approximation.

The mean sidereal month must have been deduced from the mean synodic month and the year adopted. Hence no comparison need be made of this element here.

We will now consider the sidereal periods, the nodes and the apogee of the Moon. These are shown below :-

According to	Sid. Per. of Moon's Apogee	Sid. per. of the Ascending Node
<i>Āryabhaṭīya</i>	3231.987079 da.	6794.749511 da.
<i>Khaṇḍakhādya</i>	3231.987844 da.	6794.750834 da.
<i>Brahma-sphuṭa - Siddhānta</i>	3232.73411 da.	6792.25396 da.
Ptolemy	3232.617656 da.	6796.45571 da.
Modern values (Lockyer)	3232.37543 da.	6793.39108 da.

Here also the Indian values show a closer approximation to the true values, Brahmagupta's figures representing the nearest approach.

Other Constants

So far the Indian values of the constants have been more accurate than the Greek ones ; but as to the inclination of the Moon's orbit the Greek value is more accurate than the Indian value.

Inclination of the lunar orbit

Indian value=4°30'.

Greek value= $5^{\circ}0'$.

Modern mean value= $5^{\circ}8'43''.427$ (Brown)

This discrepancy confirms the conclusion, that the observation of the Moon was restricted to the time when she was near a node, either at solar or lunar eclipses, where a small error of observation magnified itself into about half a degree.

We now turn to the parallaxes of the Sun and the Moon :-

	<i>Sun's Mean Hor. Parallax</i>	<i>Moon's mean Hor. Parallax</i>
<i>Āryabhaṭīya</i>	3'55".62	52'30"
<i>Kaṇḍakhādyaka</i>	3'56"5.	52'42".3
Ptolemy	2'51"	53'34"
Modern values	0'8".806	57'2".79

As to the Sun's horizontal parallax, the ancients were of course totally wrong, but in respect to that of the Moon their values were fairly approximate.

We next consider the angular semi-diameters of the Sun and the Moon. These are :-

	<i>Moon's Mean Semi-diameter</i>	<i>Sun's Mean Semidiameter</i>
<i>Āryabhaṭīya</i>	15'45"	16'29".4
<i>Kaṇḍakhādyaka</i> (<i>Brāhma-sphuṭa-siddhānta</i>)	16'0".22	16'15"
Ptolemy	17'40"	15'40"
Modern values	15'33".60	16'1".8

Here also the Indian values are more accurate than the Greek values.

Moon's Equations. The First Equation.

It remains now to consider the Moon's equations in ancient Indian astronomy. As has been pointed out before, obser-

variation was up to the time of Brahmagupta, restricted to the time of eclipses perhaps also of syzygies.

The modern form of the Moon's equations is

$$= 377' \sin (nt-a) + 13' \sin 2(nt-a) + \dots\dots\dots$$

$$+ 76' \sin [2(nt-\theta) - (nt-a)] + 40' \sin 2(nt-\theta) \dots\dots\dots^1$$

where nt = mean longitude of the Moon, a the longitude of the perigee, θ = longitude of the Sun.

Here the first two terms, viz., $377' \sin (nt-a) + 13' \sin 2(nt-a)$, are due to elliptic motion about the Earth in one focus; the term $76' \sin [2(nt-\theta) - (nt-a)]$ is known as the evection. We combine a part of the first term with the evection term and the expression for the equation of centre becomes $= 301' \sin (nt-a) + 13' \sin 2(nt-a) + \dots\dots\dots + 152 \sin (nt-\theta) \cos (\theta-a) + 40' \sin 2(nt-\theta)$.

Now at syzygies and eclipses $\sin (nt-\theta)$ and $\sin 2(nt-\theta)$ will very nearly vanish. Hence according to modern astronomy at the syzygies and eclipses, the chief term of the Moon's equation $= 301' \sin (nt-a)$.

This according to the *Āryabhaṭīya*

$$= 300' 15'' \sin (nt-a)$$

" " *Khaṇḍakhādyaka*

$$= 296' \sin (nt-a)$$

" " *Uttara Khaṇḍakhādyaka*

$$= 301' 7'' \sin (nt-a)$$

" " *Brāhmasphuṭasiddhānta*

$$= 293' 31'' \sin (nt-a)$$

" " Greek astronomy

$$= 300' 15'' \sin (nt-a) \\ \text{very nearly.}$$

Hence both the Greek and the ancient Indian astronomers were very near the true value of the Moon's equation at the syzygies and eclipses. Godfray in his *Lunar Theory*, page 107, observes, "the hypothesis of an excentric, whose apse has a progressive motion as conceived by Hipparchus served to calculate with considerable accuracy the circumstances of eclipses; and observations of eclipses, requiring no instruments, were then the only ones which could be made with sufficient exactness to test

1. The accurate values of the coefficients appear to be $377' 19''.06$, $12' 57''.11$, $76' 26''$ and $39' 30''$.

the truth or fallacy of the supposition." We next consider the second inequality of the Moon.

Moon's Second Inequality or Equation

In ancient times it was Ptolemy who first really found a second inequality of the Moon. According to Godfray (*Lunar Theory*, p. 107) "by dint of careful comparison of observations he (Ptolemy) found that the value of this second inequality in quadrature was always proportional to that of the first in the same place, and was additive or subtractive according as the first was so; and thus, when the first inequality was at its maximum or $5^{\circ}1'$, the second increased it to $7^{\circ}40'$ which was the case when the apse line happened to be in syzygy at the same time."

It is well known that though Ptolemy discovered the second inequality in the Moon's motion he was not able to ascertain its true nature. His corrections in this case are true when at the quadrature the Moon's apse line passes through the Sun or it is at right angles to the line joining the Earth and the Sun.¹ In the general case his construction does not lead to the elegant form of the evection term as we know it now, nor does it lead to the nice form in which it was given by later Indian astronomers from the time of Mañjula (or Muñjala, 854 Śaka era = 932 A.D.).

As has already been pointed out, the early Indian astronomers from Āryabhaṭa to Brahmagupta aimed at accuracy in lunar calculation only for the eclipses and syzygies, and did not interest themselves about the Moon's longitude at the quadratures. Hence this second inequality is absent in the works of these makers of Indian astronomy, as also in the Pre-Ptolemaic Greek astronomy. This points to the conclusion that in both the earlier Indian and Greek systems of astronomy, the modes of observation of the Moon were copied from an earlier system of astronomy whether Babylonian or Chaldean. Even in the *Romaka Siddhānta* of the *Pañcasiddhāntikā*, there is no mention of evection.² Thus inspite of the transmission of a vague system of Greek astronomy, Indian astronomy as developed by Āryabhaṭa and Brahmagupta must be regarded as independent and

1. Godfray's *Lunar Theory*, pp. 108-110.

2. Vide the Summary in P.C. Sengupta's paper, "Āryabhaṭa the Father of Indian Epicyclic Astronomy." *Journal of the Department of letters*, vol. XVIII, Calcutta University Press.

original not only from this but also from other considerations. It sought to correct the constants as were obtained from the Babylonian and the Greek systems as has in some cases been shown already.

Mañjula's Second Equation of the Moon (932 A.D.)

We now take up in detail Mañjula's second equation of Moon. It is, however, necessary to say something about his first inequality.

This is given in the form

$$\frac{-488 \sin (nt-a')}{96 + \frac{488}{120} \cos (nt-a')} \text{ degrees,}$$

where nt stands for the Moon's mean longitude, a' —that of the apogee.

Hence when $nt-a'=90^\circ$, the equation = $\frac{488}{96} = 5^\circ 4' = 304'$ showing an excess of $4'$ over the modern value.

It is further necessary to modify the expression for the Moon's modern form of the equation by changing a to $180^\circ + a$, as in ancient Indian astronomy anomaly is measured not from the perigee but from the apogee.

The modified form is

$$\begin{aligned} &= -301' \sin (nt-a) + 13 \sin 2(nt-a) \dots \\ &- 152' \sin (nt-\theta) \cos (\theta-a) + 40' \sin 2(nt-\theta) + \dots \end{aligned}$$

Mañjula's lines giving the second equation are—

The (mean) daily motion of the Moon diminished by 11° and multiplied by the "cosine" of the longitude of the Sun diminished by that of the Moon's apogee is the multiplier of the "sine" and the "cosine" of the longitude of the Moon diminished by that of the Sun, divided severally by 1 and 5. The results taken as minutes are to be applied negatively and positively to the Moon and to her daily motion if the quantities multiplied together are of opposite signs and in the reverse order if they are of the same sign.¹

1. इन्द्रचोनाककोटिष्ठा गत्यंशा विभवा विधोः ।

गुणो व्यक्तेन्दोः कोट्योरूपं पञ्चाप्तयोः क्रमात् ॥

फले शशाङ्क-तद्वशात्कोटिष्ठाधे स्वर्णयोर्वधे ।

ऋणं चन्द्रे धनं मुक्तौ स्वर्णं सान्य वधेभ्यथा ॥

As to the positive or negative character of the "sine" and the "cosine" he gives the rule:—

The mean planet diminished by its *ucca*, the apogee, aphelion or the Śighra, is called *Kendra* or mean anomaly; its "sine" from above six signs (180°) arises from half circles and are respectively positive or negative, and its "cosine" in different quadrants are respectively positive, negative, negative, and positive.¹

The convention followed is that the "sine" is negative from 0° to 180° and positive from 180° to 360° of the arc and that the cosine is positive between 0° and 90°, negative between 90° and 270° and positive between 270° and 360°.

We may now symbolically express Mañjula's second inequality thus:—

$-(13^{\circ} 11' 35'' - 11'') \times 8^p 8' \cos(\theta - \alpha) \times 8^p 8' \sin(D - \theta)$ where D stands for the Moon as corrected by the 1st equation; we leave out the correction to the Moon's daily motion as given in the stanzas quoted above.

The moon's new equation comes out to be

$$= -143'58'' \cos(\theta - \alpha) \sin(D - \theta).$$

This, it will be seen, is exactly the modern form of the evection as combined with a part of the equation of apsis shown before. The difference in the main is that Mañjula's constant is 144', a quantity less by 8'. *In form the equation is most perfect, it is far superior to Ptolemy's, it is above all praise.* It is from this inequality, we trust, that Mañjula should have an abiding place in the history of astronomy. The next writer who gives the second equation is Śripati (1028 A.D.).

Śripati's Second Inequality of the Moon

The following stanzas from Śripati's *Siddhānta Śekhara*, it is said, were communicated to Sengupta by Pandit Babua Misra. Though they are probably not very correct still the general meaning is clear. They carry the following sense:

"From the Moon's apogee subtract 90°, diminish the Sun by the remainder left; take the "sine" of the

1. ग्रहः स्वोच्चोन्नितः केन्द्रं षड्द्विदंजो भुजः ।

धनार्थः पदशः कोटिधैनर्यं धनात्मिका ॥

result; multiply it by 160' and divide by the radius; the result is called *caraphala*. Put it down in another place, multiply it by *sara* (i.e., $R \text{ vers } (D-a)$ or versed sine of the Moon's distance from the apogee) and divide by the difference between the Moon's distance (hypotenuse) and the radius; the result is called *paramaphala* (*cara phala*), which is to be considered positive or negative according as the hypotenuse put down in another place is less or greater than the radius. Multiply the "sine" of the Moon which has been diminished by the apparent Sun, by the apparent *paramaphala* and divide by the radius; the final result is to be called *caraphala* to be applied to Moon negatively or positively as the Moon minus the Sun and the Sun minus the Moon's apogee (diminished by 90°) be of opposite signs; if these latter quantities be of the same signs, the new equation should be applied in the inverse order by those who want to make the calculation of the apparent Moon agree with observation.¹

Symbolically :—

$$\frac{160' R \sin[\theta - (\alpha - 90^\circ)]}{R} = \text{caraphala}$$

$$\mp \frac{160' R \sin[\theta - (\alpha - 90^\circ)]}{R} \times \frac{R \text{ vers } (D-a)}{H-R}$$

$$= \text{paramaphala, according as } H > \text{ or } < R$$

The new equation

$$= \mp \frac{R \sin (D-\theta)}{R} \times \text{paramaphala}$$

1. त्रिभविरहितचन्द्रोच्चो नभारवद्भुजज्या ।
 गगननृपविनिष्ठी भन्नयज्या विभक्ता ॥
 भवति चरफलाख्यं तत् प्रथक् स्थं शरवर्त्त ।
 हृतमुडपतिकर्णत्रिज्ययोरन्तरेण ॥
 परमफलमवा तंतदधनार्थं प्रथकस्थे ।
 तुद्दिनकिरणकर्णे त्रिज्यकोनाधिकेऽथ ।
 स्फुटदिनकरहीनादिन्दुतो या भुजज्या ।
 स्फुटपरमफलव्नी भाजिता त्रिज्ययाप्तम् ॥
 शशिनि चरफलाख्यं सूर्यहीनेन्दुगोलात् ।
 तद्वयमुत्थनं चेन्द्रोच्चहीनाकंगोलम् ॥
 यदि भवति हि साम्यं व्यस्तमेतद् विधेयम् ।
 स्फुटगणितदृष्टेर्क्यं कर्तुं मिच्छद्भिरत्र ॥

$$\begin{aligned}
&= \mp \frac{160' R \sin[\theta - (a - 90^\circ)] R \text{ vers } (D - a) \times R \sin(D - \theta)}{R(H - R) \times R} \\
&= \mp \frac{160' R \cos(\theta - a) \times R \sin(D - \theta)}{R \times R} \times \frac{R \text{ vers } (D - a)^1}{H - R}
\end{aligned}$$

This equation is a slightly modified one but practically the same in form as that of Mañjula, except that the constant here is 160', greater than his by 16'. The constant is 160' also in Candraśekhara's form as we shall see later on. We next consider the Moon's inequalities as given by Bhāskara II in his *Bijopanaya*,* a special work on these inequalities composed in the Saka year 1074 (=1152 A.D.) two years after he had composed the *Siddhānta Śiromaṇi*.

Bhāskara II on Moon's Inequalities

His preliminary statement runs thus .—

112' positive or negative representing the maximum difference, have been found by me in the daily observed Moon (as calculated and as observed) at that point of the ecliptic where the arc from the *kadamba* (i.e., its pole) passing through the zenith cuts it.¹

Thus for observing the Moon he selected the nonagesimal as the suitable point where the uncertainty about her parallax is zero, and found $\mp 112'$ of arc to be the maximum difference between her calculated and observed places.

Mallabhaṭṭa, perhaps a contemporary of Bhāskara II, ascribed this difference to a supposed *Sighrocca* of the Moon. Bhāskara in stanzas 9-13, refutes the existence of the *Sighra* in the case of the Moon, the substance of his argument begins (i) that it is against the teaching of the *Sūrya-siddhānta* and other accepted authorities, (ii) that there is no variation of the apparent angular diameter of the Moon corresponding to this alleged *Sighra*, and (iii) that planets having a *Sighra* have retrograde motion which is never the case with the Moon.

*There is some uncertainty, about this new fraction introduced by Śripati.

1. लिप्ता विधोरकं महीमिता मे हंगोचराः प्रत्यहमीक्षितस्य ।
कदम्ब गोलगत-सूत्रपाते क्रान्ती धनर्यात्वजुषो समञ्चाद् ॥

The reasons for his new equations are stated as follows:—

When the Moon is situated at a quadrant ahead of the apogee and with the Sun at half a quadrant ahead of her, the maximum discrepancy (of 112') is seen in the negative character.

When the Moon is situated at three quadrants ahead of the apogee and with the Sun at half a quadrant behind her, the maximum discrepancy (of 112') is seen in the positive character.

When the eclipses of the Sun and the Moon take place at the apogee or the perigee of the Moon, the Moon as corrected by the equation of apsis is seen to be without any new correction called *bija*.

When the eclipses of the Sun and the Moon take place at the ends of the odd quadrants of the Moon's anomaly (measured from the apogee), the discrepancy is seen to be less by 34'.

When the Moon is at the apogee, whether the Sun be ahead or behind her by half a quadrant, the discrepancy amounts to be 34'.

The same discrepancy of 34' is observed when the Moon is at the perigee and the Sun is ahead or behind her by the same distance.

Thus by analysis and synthesis, and by repeated observations, this variable correction has been devised by me; let it be seriously considered by the learned.¹

Bhāskara here speaks of six cases and we consider them one after another:—

The Moon's equations as modified to suit *siddhāntas* are given by

$$-301' \sin (nt - \alpha) + 13' \sin 2(nt - \alpha) \dots$$

$$-152' \sin (nt - \theta) \cos (\theta - \alpha) - 40' \sin 2(nt - \theta) + \dots$$

According to Bhāskara's *Siddhānta - siromani*, the Moon's equation of apsis

$$= -\frac{31^\circ 36'}{360^\circ} \times 3438' \sin (nt - \alpha)$$

$$= -301' 46''.8 \sin (nt - \alpha),$$

this agrees well with the corresponding term of the modern equation. As Bhaskara takes in all the six cases, $nt - \alpha = 90^\circ$, 270° , 0° or 180° , the second term of the equation of apsis vanishes.

Case I.

$$nt - \alpha = 90^\circ, nt - \theta = -45^\circ, \theta - \alpha = 135^\circ;$$

Here the total equation of the Moon

$$= -301' - (76' + 40') = -301' - 116'.$$

This fairly agrees with Bhāskara's observation, the difference being only of $4'$.

Case II.

$$nt - \alpha = 270^\circ, nt - \theta = 45^\circ, \theta - \alpha = 225^\circ;$$

the total equation of the Moon

$$= 301' + 76' + 40' = 301' + 116'.$$

This also agrees with Bhāskara's observation.

Case III.

$nt - \alpha = 0^\circ$ or 180° , $nt - \theta = 0^\circ$ or 180° , $\theta - \alpha = 0^\circ$ or 180° , the total equation $= 0'$, this also agrees with Bhāskara's observation.

Case IV,

$$nt - \alpha = 90^\circ \text{ or } 270^\circ, nt - \theta = 0^\circ \text{ or } 180^\circ, \theta - \alpha = 90^\circ \text{ or } 270^\circ,$$

1. तुङ्गादाद्यपदान्तस्थाद् विधोरकै पदाङ्कतः ।

परमं चन्द्रवैषम्यं ऋणत्वेन समीक्ष्यते ॥ 20 ॥

तत् तृतीय पदान्तस्थाद् पृष्ठगेऽर्के पदाङ्कतः ।

परमं चन्द्रवैषम्यं धनत्वेन समीक्ष्यते ॥ 21 ॥

चन्द्रतुङ्गे च नीचे च शशाङ्कार्कग्रहौ यदि ।

मन्दस्फुटगतश्चन्द्रो निर्धोजतुल्यमीक्ष्यते ॥ 22 ॥

श्रोजान्तयोर्विधोस्तुङ्गाच्छराङ्कार्कग्रहौ यदि ।

चतुरिन्शत्कलादीनि वैषम्यं तु समीक्ष्यते ॥ 23 ॥

अग्रतः पृष्ठतो वाऽपि रवेरचन्द्रे पदाङ्कगे ।

तुङ्गतुल्ये चतुरिन्शत् कलावैषम्यमीक्ष्यते ॥ 24 ॥

एवं तन्नीचतुल्येऽपि वैषम्यं तावदेव हि ।

एवं व्यासात् समासाच्च पौनःपुन्येन वैयनात् ॥

चरवीजमिदं कल्पं रुषा सद्भिः समीक्ष्यताम् ॥ 25 ॥

the total equation = $\mp 301'$. This does not agree with Bhāskara's statement that the total equation
 $= \mp (301' \pm 78')$.

Case V.

$$nt - a = 0, nt - \theta = \pm 45^\circ, \theta - a = \pm 45^\circ,$$

the total equation

$$= 0' - 76' + 40' = -36' \text{ or } 0' + 76' - 40' = +36'.$$

This fairly agrees with Bhāskara's observation.

Case VI.

$$nt - a = 180^\circ, nt - \theta = \pm 45^\circ, \theta - a = 180^\circ \mp 45^\circ$$

the total equation

$$= 0' + 76' + 40' = 0' + 116', \text{ or } 0 - 76 + 40 = 0' - 36'.$$

This does not agree with Bhāskara's statement.

Bhāskara then states his first system of 24 equations corresponding to 24 sines in a quadrant to be 6', 13', 21', 27', 33', 39', 45', 51', 56', 61', 65', 68', 70', 72', 74', 75', 75', 76', 76', 77', 77', 78', 78', 78'.¹

These equations, he says—"are negatively added to the equation of apsis when that is negative and positively added to the same when that is positive"². In other words his new equations are complements of the equation of apsis, the two together being represented by

$$-301' 46". 8 \sin (nt - a) - 78' \sin (nt - a)$$

$$\text{i.e., by } -379' 46". 8 \sin (nt - a).$$

Hence next states his second set of equations depending on $\theta - D$, to be 6', 9', 13', 17', 22', 24', 27', 30', 32', 33', 34', 34', 34', 33', 31', 29', 26', 24', 20', 16', 11', 8', 3', 0' and says :

"These minutes are negative in the odd quadrants of the argument and are positive in other quadrants."³

When the value of the argument is 15° , the equation is 17',

"	"	"	45°	"	34'
"	"	"	90°	"	0'

1. *Bhājanaya*, 26-28.

2. "फलं ऋणे ऋणं ।

धने धनं मन्दफलेन संयुतम् ॥ 28 ॥

3. *Bhājanaya*, 29-32.

4. पताः कला श्रोजपदे ऋणं स्थुर्धनं तदन्यत्र भवन्ति भूयः ।

$$\begin{aligned}\text{Hence the new equation} &= -34' \sin 2(\theta - D), \\ &= 34' \sin 2(D - \theta).\end{aligned}$$

Here the symbol D stands for the Moon as corrected by the ancient Indian equation of apsis and its complement as given by Bhāskara. It is readily seen that Bhāskara is the first of all the Indian astronomers to detect the equation known as "Variation" His constant, $34'$, is less than the modern value by about $6'$, and cannot be considered as a serious error.

We now see that the sum-total of the Moon's equation as given by Bhāskara

$$= -379' 46''.8 \sin(nt - a) + 34' \sin 2(D - \theta),$$

the evection term being totally absent. This is a serious defect, and Bhāskara's new equations would make the Moon generally more incorrect at the syzygies and eclipses than what the ancient Indian equation of apsis would do.

Perhaps late in life when he was 69 years old in 1105 of Śaka era (=1183 A.D.) he discovered the inapplicability of his new equations at the times of eclipses and in his *Karaṇa-kuttahala* he altogether omitted these new equations which he had given in his *Bijopanaya*.

As to Bhāskara's second inequality which is really the complement of the equation of apsis without the evection term, it is far inferior to that of Mañjula and of Śrīpati; as we have seen their form of the second inequality combines the complement of the equation of apsis and evection in the mathematically correct form. For the discovery of such a form of the equation as of these authors, very patient, careful and frequent observation must have been coupled with very careful and nice comparison of observed facts.

As to "variation" it was first discovered by Abul-Wefa in 976 A.D.¹ which was quite forgotten when Tycho-Brahe re-discovered it in 1580 A.D. Hence Bhāskara in 1152 A.D., re-discovered it in India four centuries before Tycho.

Candraśekhara of Orissa on the Moon's Inequalities

In connection with lunar inequalities it is necessary here to record what were the equations discovered or verified by M.M. Candraśekhara Siṃha of Orissā in the later half of the last century. He was educated in the orthodox Sanskrit fashion

1. Godfray's *Lunar Theory*, p. 114.

and had no acquaintance with English education. His work *Siddhānta-darpaṇa* was edited by Prof. Jogeschandra Ray, late of the Cuttack College, in 1899.¹ Candrasekhara in his work gives four equations of the Moon which are :-

- (1) The equation of apsis.
- (2) The Tungānta equation or the complement of the equation of apsis in combination with evection.
- (3) The fortnightly equation or variation.
- (4) The Digamśa equation or the annual equation (i. e., $\frac{1}{12}$ of the Sun's equation).
- (5) The first equation is of the form

$$\begin{aligned}
 &= \frac{[31^\circ 30' - 30' \cos (nt - a)] 3438 \times \sin (nt - a)}{360^\circ} \\
 &= -300' 49''.5 \sin (nt - a) + 4' 46''.5 \sin (nt - a) \cos (nt - a) \\
 &= -300' 49''.5 (\sin nt - a) + 2' 23''.25 \sin 2 (nt - a)
 \end{aligned}$$

It is seen that Candrasekhara wanted to correct the equation of apsis to the second order of small quantities as in all the Indian authors from Brahmagupta but Candrasekhara's form is correct though his constant is wrong.

- (2) His second equation is of the form

$$\begin{aligned}
 &\frac{160' \times 3438 \sin[\alpha - (\theta + 90^\circ)]}{3438} \times \frac{3438 \sin(D - \theta)}{3438} \\
 &\times \frac{\text{Moon's appt. daily motion}^2}{\text{Moon's mean motion}}, \\
 &= -160' \cos (\theta - \alpha) \sin (D - \theta) \\
 &\times \frac{\text{Moon's appt. daily motion}}{\text{Moon's daily mean motion}}
 \end{aligned}$$

Here the constant is the same as that of Śrīpati discussed before. The symbol means the Moon as corrected by the equation of apsis. It is readily seen that the constant of the first term of the equation of apsis is increased by 80'. and that the constant of evection is taken at 80'. In both the cases the error is about +4'.

- (3) Candrasekhara's third equation or Variation

$$= \frac{3438' \sin 2(D' - \theta)}{90} = 38' 12'' \sin 2(D' - \theta),^3$$

1. *Siddhānta-darpaṇa*, V, 100-114.
 2. *Ibid*, VI, 7-9
 3. *Siddhānta-darpaṇa* VI. 11-12.

where D' means the Moon as corrected by the 1st and the 2nd equations. Here the constant is wrong by $-1' 18''$.

(4) His fourth equation or the annual equation
 $= \pm \frac{1}{10}$ of the Sun's equation of apsis,¹

$= \pm \frac{1}{10} \times \frac{12 \times 3438}{360} \sin$ (Sun's distance from the apogee).

$= \pm 11' 27''.6 \sin$ (Sun's distance from the apogee).

The modern value of the constant is $11' 10''$. Tycho found it to be $4' 30''$. Horrocks' (1639) co-efficient was $11' 51''$.

As Candrasekhara was aware of Bhāskara's *Bijopanaya*, as also of the work of Śrīpati, his merit here lies in the discovery of the annual equation, and correction to the constant of variation.

Thus we have seen that so far as the luni-solar astronomy is concerned Indian astronomy is independent of Greek astronomy in respect of astronomical constants, that Indian astronomy is generally more accurate than Greek astronomy and that Indian astronomers were not mere "calculators"². There were observers who verified and corrected the old astronomical constants as they came down from Āryabhaṭa and Brahmagupta, who also found independently all the principal equations of the Moon.

1. Siddhānta darpaṇa VI. 13.

2. G.R. Kaye *Hindu Astronomy*, p. 60

— o : —

Reference

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 Godfray : *Lunar Theory*.

CHAPTER VII

Greek and Hindu Methods in Spherical Astronomy

Here we shall reproduce from Sengupta's paper a comparative account of the Greek and ancient Indian methods in Spherical Astronomy and to bring out the independence of the Indian Astronomers on this subject. The views on this subject would necessarily differ from those of many European scholars such as Colebrooke and Bentley (early 19th century) to Kaye (early 20th century). Kaye wrote as follows in the *Journal of Asiatic Society of Bengal* 1919, No. 3.

The methods by which (the rules) were obtained are buried in obscurity. Braunmühl¹ has stated "that the Indians were the first to utilise the method of projection in the Analemma of Ptolemy." It is intended to present the Hindu methods as clearly as possible and to show that Braunmühl has not done sufficient justice to the Indian astronomers.

As to Kaye, we shall show that his remark quoted above is due to the fact that he had to rely mostly on the English translation of the *Sūryasiddhanta* of Burgess, and perhaps he had no access to the works of Bhāskara II (1150 A.D.), who was the first to explain the ancient Indian methods clearly.

Greek and Hindu Methods in Spherical Astronomy

Of the Greek methods in Spherical Astronomy, the history begins with elementary principles only from Euclid (300 B.C.). Even in Theodosius' *Sphaerica*² (about 153 B. C.) "there is nothing that can be called trigonometrical." Heath again says,

1. Heath, *Greek Mathematics*, Vol. II, p. 291. Braunmühl, *Geschichte der Trigonometrie*, pp. 38-42.
2. Heath, *Greek Mathematics*, Vol. II, p. 250.

"the early spheric did not deal with the geometry of the sphere as such, still less did it contain anything of the nature of the spherical trigonometry. (This deficiency was afterwards made good by Menelaus's *Sphaerica*).¹ Hence the Greek spherical trigonometry began with Menelaus (90 A.D.). His theorem in geometry is well-known—"If the sides of a plane triangle be cut by a transversal into six segments, the continued product of any three alternate segments, is equal to the continued product of the remaining three." From this proposition he deduced the so-called "*regula sex quantitatum*" or the theorem, if the sides of a spherical triangle be cut by an arc of a great circle into six segments, the continued product of the chords of the doubles of any three alternate segments is equal to the continued product of the chords of doubles of the remaining three segments." In plane geometry if the sides BC, CA, AB of a triangle be cut by any transversal at L, M, N, respectively, L then we have

$$\frac{BL}{LC} \cdot \frac{CM}{MA} \cdot \frac{AN}{NB} = 1.$$

In spherics the theorem is :

$$\frac{\text{Chord } 2 BL}{\text{Chord } 2 LC} \cdot \frac{\text{Chord } 2 CM}{\text{Chord } 2 MA} \cdot \frac{\text{Chord } 2 AN}{\text{Chord } 2 NB} = 1$$

Both these theorems are proved in A Ptolemy's *Syntaxis* (Karl Manitius's edition, Vol. I, pp. 45-51).

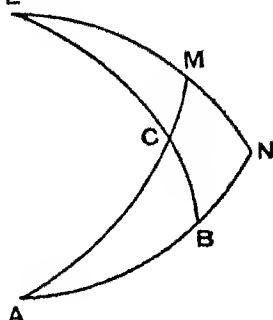


Fig. 5

If R be the radius of the sphere on which the spherical triangle ABC is constructed, then the chord of the arc $2 BL = 2 R \sin BL$. Hence Menelaus's theorem in spherics may be expressed as follows :

$$\frac{\sin BL}{\sin LC} \cdot \frac{\sin CM}{\sin MA} \cdot \frac{\sin AN}{\sin NB} = 1$$

This theorem is true for any spherical triangle.

If $\angle B = \angle A = \angle M = 90^\circ$ and L the pole of AB, then LMN is a secondary to the arc AB. There are four arcs of great circles; taking any three as forming a spherical triangle and the fourth as the transversal we readily get for the right-angled

1. A.A. Björnbo, "Studien über Menelaos' Sphaerik" in *Abhandlungen Zur Geschichte der Mathematischen Wissenschaften* for 1902, pp. 89 et seq.; also Heath, *Greek Mathematics*, vol. II p. 261-73.

triangle ABC, the relations :--

$$(i) \sin a = \sin b \sin A$$

$$(ii) \sin c = \tan a \cot A$$

$$(iii) \cos b = \cos a \cos c$$

$$(iv) \tan c = \tan b \cos A$$

The above are some of the Napier's rules for a right-angled spherical triangle, deducible from Menelaus's theorem¹. They are generally sufficient in the case of such triangles. In any spherical triangle, however, this theorem of Menelaus does not in any single step lead to any of the equivalents of the time-altitude or altazimuth equations in spherical astronomy. The ancient Indian methods, though none of them are so highly finished as Menelaus's theorem, yet are not less powerful in tackling the problems that arise in astronomy in connection with the apparent diurnal motion of the heavens. The Greek or Ptolemaic method presents no further points of interest except in its application. We now proceed to illustrate the ancient Indian methods and shall refer to the Ptolemaic method as occasion arises.

Ancient Indian Methods in Spherical Astronomy

In the Indian methods there is no general rule to follow. It is by properties of similar right-angled triangles that a fairly complete set of accurate formulae are obtained. These right-angled plane triangles are classified under the names,—'Krānti-kṣetras' (triangles of declination) and 'Akṣa-kṣetras' (triangles of latitude). We consider the following problems :—

Problem :- To find the time of rising on the equator of a length l , of arc of the ecliptic measured from the first point of Aries.

Let ω be the obliquity of the ecliptic and R. A. the right ascension corresponding to the longitude l , and δ the corresponding declination. The Indian form of the equation is :

1. Three more can be deduced similarly, namely,

$$(v) \sin c = \sin b \sin C$$

$$(vi) \sin a = \tan c \cot C$$

$$(vii) \tan a = \cos C \tan b.$$

* $R \sin R.A. = \frac{R \sin l \times R \sin \omega}{R \cos \delta}$, where R is the radius of the sphere.

Note:— If R be the radius of the circle of reference, the Indian trigonometrical functions for the arc θ , are (1) the 'sine,' (2) the 'cosine' and (3) the versed sine. They are respectively equal to $R \sin \theta$, $R \cos \theta$ and $R \text{ vers } \theta$.

In the adjoining figure, O is the centre of the armillary sphere, $YQ.YC$ are quadrants of the equator and the ecliptic, respectively. P is the celestial pole, PCQ the summer solstitial colure. Join OY , CQ , OP and OC .

Let $YS = l$, $YM = R.A.$, $CQ = \angle SYM = \omega$, $SM = \delta$.

Join OS , OM . PSM is the secondary to the equator.

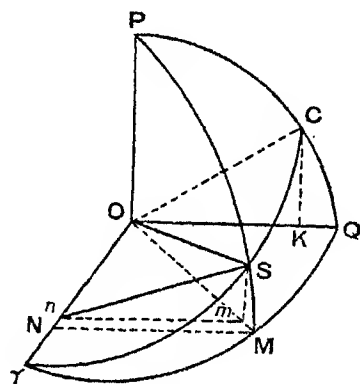


Fig. 6

From C draw CK perpendicular to OQ . From S draw Sm and Sn perpendicular to OM and OY , respectively. Join MN and from M draw MN perpendicular to OY .

Then the triangles Smn and CKO are similar. They are called '*Krānti-kṣetras*'¹ or declination triangles,—similar right-angled triangles having one acute angle $= \omega$.

$$\therefore Sm : Sn = CK : OC$$

$$\text{or } R \sin \delta : R \sin l = R \sin \omega : R$$

$$R \sin \delta = \frac{R \sin l \times R \sin \omega}{R} \quad \dots\dots(I)$$

The *Āryabhaṭīya*, Gola, 25. Varāhamihira, in the *Pañcasiddhāntikā* (IV. 92) states it in the form $2R \sqrt{\frac{(R^2 \sin^2 l) - R^2 \sin^2 \delta}{2R \cos \delta}}$

$= R \sin R.A.$, which is evident from figure. Brahmagupta's equation is identical with that of Āryabhaṭa, (*BrSpSi*. III. 15, *Sūrya-siddhānta* III. 40-41.

Also Bhāskara II, *Grahagaṇita* cap. VIII, stanzas 54-55, is in agreement with Varāhamihira's forms.

Greek Method

In the same figure¹ let PSC be the triangle and γMQ be the transversal. Then Menelaus's theorem gives

$$\frac{\sin PM}{\sin MS} \times \frac{\sin Sy}{\sin \gamma C} \times \frac{\sin CQ}{\sin QP} = 1$$

$$\text{or} \quad \frac{1}{\sin \delta} \times \frac{\sin l}{1} + \frac{\sin \omega}{1} = 1$$

$$\text{or} \quad \sin \delta = \sin l \times \sin \omega.$$

Indian Method

Again by the Indian method from the same two similar triangles we get

$$mn : nS = OK : OC$$

$$\text{or,} \quad mn : R \sin l = R \cos \omega : R$$

$$\therefore mn = \frac{R \sin l \times R \cos \omega}{R}$$

$$\text{Again } MN : mn = OM : Om$$

$$\text{i.e., } R \sin R.A. : mn = R : R \cos \delta$$

$$\therefore R \sin R.A. = \frac{R \sin l \times R \cos \omega}{R \cos \delta}$$

Greek Method

Take PQM for the triangle and γSC for the transversal.

$$\text{Then,} \quad \frac{\sin PC}{\sin CQ} \times \frac{\sin QY}{\sin \gamma M} \times \frac{\sin MS}{\sin SP} = 1$$

$$\text{or} \quad \frac{\cos \omega}{\sin \omega} \times \frac{1}{\sin R.A.} \times \frac{\sin \delta}{\cos \delta} = 1$$

$$\text{or} \quad \sin R.A. = \tan \delta \cot \omega,$$

The Indian form of the equation is different from that of Ptolemy's. It is also better for the purpose of calculation.

Note :—From the same two similar triangles we have

$$On : ON = R \cos \delta : R$$

$$\therefore On : R \cos l = \frac{R \cos R.A. \times R \cos \delta}{R} \quad \dots\dots(3)$$

$$\text{Again, } \tan R.A. = \frac{mn}{on}$$

$$= \frac{R \sin l \times R \cos \omega}{R \times R \cos l} \quad \dots\dots(4)$$

$$\text{Again, } mn : Sm = OK : KC$$

1. Manitius' Edition of *Syntaxis*, I, 51-53.

circle of a heavenly body with declination δ , NEHW the horizon, PEP' W the six O' clock circle. Here AA' the line of intersection of the diurnal circle with the horizon is called the "*udayāsta-sūtra*"¹ (or the thread joining the rising and setting points). SS' the line of intersection of the diurnal circle and the six o' clock circle, is the horizontal diameter of the diurnal circle. From S draw SK and SL perpendiculars respectively to AA' and EW. Join KL.

Now since PN= ϕ , the latitude of the station, in the small right-angled triangle KLS, the \angle KLS is also= ϕ .

$$\therefore SK : SL = QM : MO$$

$$\text{or } SK = \frac{SL \times QM}{MO} = \frac{R \sin \delta \times R \sin \phi}{R \cos \phi}$$

Now SK² is a "sine" in the small circle AB A'B' of which the radius is R cos δ ; this "sine" reduced to the equator (radius R) is the 'sine' of *cara*.

$$\begin{aligned} \therefore R \sin ch &= R \sin EPA \\ &= \frac{R \sin \delta \times R \sin \phi \times R}{R \cos \phi \times \cos \delta} \end{aligned}$$

Greek Method

Let³ the arc PA be produced to meet the equator at C. Take PCQ' for the triangle and EAN for the transversal. Then we get,

$$\begin{aligned} \frac{\sin PA}{\sin AC} \times \frac{\sin CE}{\sin EQ'} \times \frac{\sin Q'N}{\sin NP} &= 1 \\ \text{or } \frac{\cos \delta}{\sin \delta} \times \frac{\sin CE}{1} \times \frac{\cos \phi}{\sin \phi} &= 1 \\ \therefore \sin CE = \sin ch &= \frac{\sin \phi \times \sin \delta}{\cos \phi \times \cos \delta} \end{aligned}$$

Note—The perpendicular distance between AA' and Ew is called the 'sine' of the amplitude or the '*Agrā*' which is thus calculated :—

$$\begin{aligned} KL : LS &= QO : OM \\ \therefore {}^4R \sin \text{amplitude} &= 'Agrā' = KL \\ &= \frac{LS \times QO}{OM} = \frac{R \sin \delta \times R}{R \cos \phi} \end{aligned}$$

It is now evident that the ancient Indian method is different

1. Bhāskara, *Gola*, VII, 39.

2. This is called by the name '*kujyā*' or '*ksitiijyā*', i. e., earth-sine. Āryabhaṭa, *Gola*, 26, Brahmagupta, II, 57, *Sūrya-siddhānta*, II, 61 etc.

3. Manitius, *ibid*, p. 84.

4. Āryabhaṭa, *Gola*, 30, etc.

from the Greek method in this case also. As the triangle KLS is difficult to show in the diagram, it is shown in its projection on the meridian plane in Burgess's translation of the '*Sūrya-siddhānta*,' (page 232) and also in Wilkinson and Bāpūdeva Śāstrī's translation of the '*Siddhānta Śiromani*,' p. 175. This has led Braunmühl to assume that the Indian method of arriving at the equation of ascensional difference and some other equations of spherical astronomy has its origin in the Analemma of Ptolemy. A careful study, however, does not justify the identification of Indian methods with the graphic method of the Analemma, which is deduced from the projections of the position of a heavenly body on the meridian prime vertical and the horizon. It is being presently shown that what was done out of difficulty in drawing the figures properly has been taken by Braunmühl as a Greek connection.

Problem III¹ :—

To find the "Time-altitude" Equation

If from any point S on the diurnal circle a perpendicular be drawn to the *Udayāsta-Sūtra* spoken of before, this perpendicular is called the *cheda* or '*iṣṭahṛti*.' The perpendicular from S on the horizon is called '*Śanku*'² the sine of the altitude. The line joining the foot of the '*Śanku*' and that of the perpendicular on the '*Udayāsta-Sūtra*' goes by the name of '*Śankutala*' and this *Śankutala* lies to the south of the '*Udayāsta-Sūtra*' during the day.

In this figure (Fig 8) if AA' be the '*Udayāsta-Sūtra*' or the intersection of the diurnal circle and the horizon, and S a point on the diurnal circle denoting a position of the Sun, SK, SL perpendiculars on AA' and the horizon respectively; SL is called the '*Śanku*,' SK the '*cheda*' and LK, the '*Śankutala*'. In this triangle KSL, the angle KSL was recognised to be the latitude of the station.

Thus the triangle SKL is not taken in its projection on the meridian plane. The side SK is taken 'as formed of two parts.

1. Āryabhaṭa could not arrive at the true equation. Cf. Gola 28. The correct rules occur in *Pañcasiddhāntikā*, IV, 42, 44; *Brāhmasphuṭasiddhānta*, III, 36-38, 26-40; *Sūryasiddhānta*, III, 34-35.

2. Bhāskara says : ग्रहस्थानात्सन्धः शंकुः । तस्य तलमुदयास्तसूत्राद्विण्णतो भवति ॥

"Gola, VIII-39-41, Āryabhaṭa uses the term शङ्कुवृत्तम्" Gola, 29.

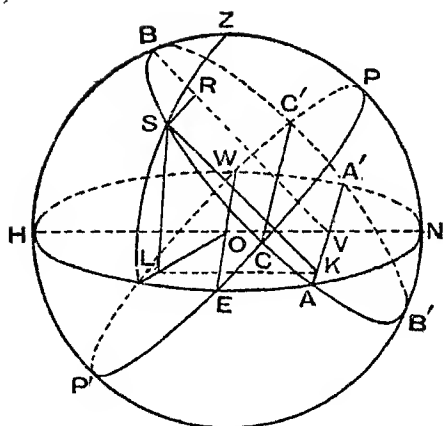


Fig. 8

'*Kujyā*.' This '*Kalā*' is constructed from the point S in the diurnal circle. Thus the triangles like SKL were not taken in their projections on the meridian plane as Braunmühl would suggest.

From the triangle KSK, we get.

'*Cheda*' : '*Sanku*' = $R : R \cos \phi$ where ϕ is the latitude of the observer;

'*Sanku*' is here = $R \cos Z$, Z being the Sun's zenith distance.

$$\therefore \text{'cheda'} = \frac{R \cos Z \times R}{R \cos \phi}$$

Now '*Cheda*' = radius of the diurnal circle + *Kujyā* — versed sine of the hour-angle in the diurnal circle $O'B + O'V - BR$,

$$= R \cos \delta + \frac{R \sin \delta \times R \sin \phi}{R \cos \phi} - \frac{R \text{ vers } H \times R \cos \delta}{R}$$

As in the previous problem, $Kujyā = SK = \frac{R \sin \delta \times R \sin \phi}{R \cos \phi}$

$$\text{or } \frac{R \cos Z \times R}{R \cos \phi} = \frac{R \cos \delta}{R} \left\{ R + \frac{R \sin \delta \times R \sin \phi}{R \cos \phi} \times \frac{R}{R \cos \delta} - R \text{ vers } H \right\}$$

The above equation simplified becomes

$$\cos Z = \sin \delta \sin \phi + \cos \delta \cos \phi \cos H.$$

In this connection we consider the altazimuth equation by the Indian method.

1. Bhāskara's *Grahaganita*, VIII, 55.

O' is the middle point of CC' or it is the centre of the diurnal circle ABB'.

Let CC' be the line of intersection of the diurnal circle and the 'six o'clock' circle EPW. Let SK cut CC' in M. Then.

$$SK = SM + MK$$

Here SM, the 'sine' in the diurnal circle of the complement of the hour angle is given a distinct name '*Kalā*' and MK as explained before is known by the name

¹Problem IV :—

The Altazimuth Equation

Indiad Method

Let α denote the azimuth of the Sun from the south. In the same triangle SKL in the same figure, we have,

$$LK : SL = R \sin \phi : R \cos \phi$$

$$\text{or, 'Śankūtala' : 'Śanku' = } R \sin^2 \phi : R \cos \phi$$

$$\therefore \text{'Śankūtala'} = \frac{R^1 \cos Z \times R \sin \phi}{R \cos \phi}$$

Now 'Śankūtala' is made up of two parts, namely, 'Bāhu' and 'Agrā,' of which the former is the distance of L from the observer's East-West line; the 'Agrā' has been already found.

$$\text{Here 'Bāhu'} = \frac{R \sin Z \times R \cos \alpha}{R} \text{ and 'Agrā'} = \frac{R \sin \delta \times R}{R \cos \phi}$$

$$\therefore \text{'Śankūtala'} = \text{'Bāhu'} + \text{'Agrā'}$$

$$\text{or } \frac{R \cos Z \times R \sin \phi}{R \cos \phi} = \frac{R \sin Z \times R \cos \alpha}{R} + \frac{R \sin \delta \times R}{R \cos \phi}$$

$$\text{or } R \sin \delta = \frac{R \cos \phi}{R} \left(\frac{R \cos Z \times R \sin \phi}{R \cos \phi} - \frac{R \sin Z \times R \cos \alpha}{\phi} \right)$$

which is easily seen to be equivalent to

$$\sin \delta = \cos Z \sin \phi - \sin Z \cos \phi, \cos \alpha$$

Greek Method

Ptolemy² has also a method of finding the Sun's altitude at any hour of the day. His method is as follows :—

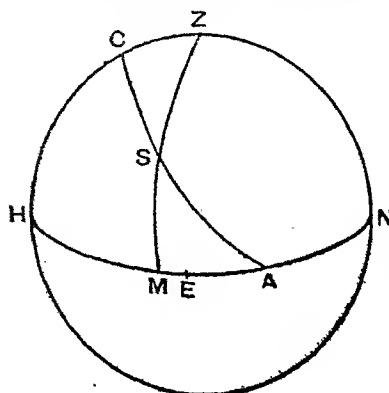


Fig. 9

(i) He would find by means of his tables for the times of risings of the signs of the zodiac, the orient ecliptic point. (ii) He would then find the culminating point of the ecliptic. (iii) He would finally apply Menelaus's theorem in spherics thus :—

Let ASC be any position of the ecliptic. (Fig. 9) NZC the

1. The equivalent of this, in a particular case, is first found in *Brāhma. sphuṭasiddhānta*, Ch. III, 54-56 Cf. *Sūryasiddhānta*, III, 28-31, also *Bhāskara Grahaganita*, IX, 50-52.

2. Manitius, *ibid*, pp, 118, 19.

meridian, NAMH the horizon, Z, the zenith and S the Sun. Here the celestial longitudes of C, S and A are taken to be known; hence ZC and CH are also known.

Now take ZCS for the triangle and HMA to be the transversal ; we then have by Menelaus's theorem.

$$\frac{\sin ZH}{\sin HC} \times \frac{\sin CA}{\sin AS} \times \frac{\sin SM}{\sin MZ} = 1$$

$$\text{or } \sin SM = \frac{\cos CZ \times \sin AS}{\sin CA}$$

It is thus clear that Ptolemy had no direct method for connecting the Sun's altitude and the hour-angle. This method is workable for the problem "given time, find the altitude" but is not workable in the converse problem ; besides, the calculation of the longitudes of A and C is very cumbrous.

Again, when EA has been found out, taking ZHM for the triangle and CSA for the transversal, we get,

$$\frac{\sin HA}{\sin Am} \times \frac{\sin MS}{\sin SZ} \times \frac{\sin ZC}{\sin CH} = 1, \text{ whence and thence HM,}$$

the azimuth can be found. The method is here also cumbrous, there being no direct connection between altitude and azimuth ; besides the time-element is not avoided.

The Analemma of Ptolemy and the Indian Method.

When the Sun's declination is zero and his hour-angle, is H, Zeuthen¹ following the method of the 'Analemma' of Ptolemy, as explained by Braunmühl² has deduced the following equations :

$$(1) \cos Z = \cos H \cdot \cos \phi$$

$$(2) \tan a = \frac{\tan H}{\sin \phi}$$

To these two, Heath following Braunmühl adds

$$(3) {}^3\tan ZQ = \frac{\tan H}{\cos \phi}$$

1. Heath, *Greek Mathematics*, Vol. II, pp. 290-91.

Zeuthen, *Bibliotheca Mathematica*, 13, 1900, pp. 23-27.

2. Braunmühl, *ibid*, pp. 12-13.

3. The Indian form of this equation is $R \sin ZQ = \frac{R \sin H \times R}{\sqrt{R^2 - R^2 \cos^2 H \times R^2 \sin^2 \phi}}$
R

Bhāskara's, *Golādhyāya*, Com. on VIII, 67.

where Z is the zenith and Q is the point of intersection of the prime vertical and its secondary passing through the Sun and the north-south points.

Zeuthen¹ points out that later in the same treatise Ptolemy finds the arc 2 β described above the horizon by a star of given declination δ' by a procedure equivalent to the formula.

$$(4) \cos \beta = \tan \delta' \tan \phi.$$

With regard to the 'Analemma' of Ptolemy, it may be noted, as Heath² says, that "the procedure amounts to a method of graphically constructing the arcs required as parts of an auxiliary circle in one plane." Many things may be, in practice, done graphically far more easily than by the theoretical method. Besides, no theoretical calculations occur in the 'Analemma'. Zeuthen³, following the method of this work, has deduced in the general case, the two equations.

$$(5) \cos Z = (\cos \delta, \cos H + \sin \delta, \tan \phi) \cos \phi.$$

$$(6) \tan \alpha = \frac{\cos \delta \sin H}{\frac{\sin \delta}{\cos \delta} + (\cos \delta \cos H + \sin \delta \tan \phi) \sin \phi}$$

These equations are suggested to a modern reader from a study of the figures in the 'Analemma.' But neither in this work nor in the 'Syntaxis' are they to be found. With regard to the first four formulae, it is possible that they were recognised by Ptolemy. With regard to the last two, Zeuthen³ remarks "mais le texte n'en contient rien," and they were certainly not recognised by Ptolemy.

Besides the tangent function is wholly absent in Greek trigonometry. They are also different in form from those arrived at by the Indian method as explained before. Thus, it is clear that the Indian methods are in no way connected with the method of the 'Analemma.'

Even taking for granted that the Indians followed a method of projection much allied to the method of the 'Analemma' there is no adequate reason for assuming that their method is derived from any Greek source. Analogy and precedence do not necessarily constitute originality—there is still the chance of a remoter origin from which both the systems drew their inspiration. The method of the 'Analemma,' as has been already stated, presents a

1, 2, Björnbo, *loc. cit.* p. 86.

3. Zeuthen, *loc. cit.* p. 27.

graphical method for constructing the Sun's altitude and azimuth from the hour angle when the Sun's declination is zero but such a graphical method is generally complex as compared with the elegant Indian method. An astronomer who constructs and uses an armillary sphere to arrive at his equations in spherical astronomy and who has not a well-developed spherical astronomy at his command must have to draw perpendiculars from the positions of the heavenly body, not only on the meridian plane, the horizon or on the prime vertical, as the occasion arises, but also on the line of intersection of the diurnal circle with the horizon. Hence Braumühl's statement that the Indian methods of spherical astronomy have their origin in the 'Analemma's, in spite of his admitting that Indians were first to utilise its methods, is rather far-fetched and tends to take away the honour from the great Indian astronomers, who devised the beautiful methods. The 'Analemma' as it now exists is a Latin translation from an Arabic version of the original Greek¹. We may reasonably doubt that the Arabic version was greatly influenced by the ancient Indian system.

We now pass on to the consideration of other allied or similar problems in the two systems of astronomy.

Problem V—

To find the Angle between the Ecliptic and the Meridian

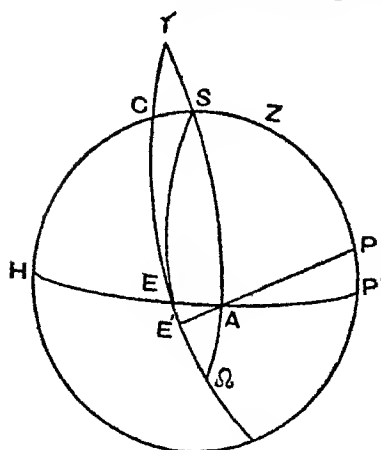


Fig. 10

Indian Method²

Let γSA be the ecliptic, γCE the equator, E the east-point of the horizon (Fig 10). Cut off $SH=90^\circ$ and draw the great circle $HEAP'$ cutting the meridian $P'SCH$ at the points P' and H . The aim is to find AP' but it is enough to find EA since AP' is the complement of EA' .

Both Āryabhaṭa and Brahmagupta were unable to find EA correctly. Let P be the celestial pole and let PAE' be

1. On the influence of the ancient Indians on Arab mathematics and astronomy; see Alberuni's *India*, translated by Dr. E. Sachau, Vol. II, p. 304.

2. Āryabhaṭa, *Gola*, 45; *BrSpSi*, IV. 17; *Sūrya-siddhānta*, IV. 25; Bhāskara's *Golādhyāya*, VIII, 21-74, first example in his own commentary.

the secondary to the equator cutting it at E'. Both the above astronomers were content with the idea that $AE=AE'$, or that AE =the declination of the point A of the ecliptic which is 90° ahead of S in the above figure. This idea continued till the time of Bhāskara II (1150 A. D.) who found out the correct equation.

He recognised that CS, the declination of $S=PP'$; P'EH is then the horizon of the station whose north geographical latitude is CS. Also, the 'sine' of EA is the 'Agyā' or the sine of the amplitude of the point A for the latitude CS.

$$\therefore R \sin EA = \frac{R \sin AE' \times R}{R \cos CS} = \frac{R \sin (90^\circ + \gamma S) \times R \sin \omega}{R} \\ \times \frac{R}{R \cos CS}$$

$$\text{or } R \sin EA = \frac{R \sin (90^\circ + l) \times R \sin \omega}{R \cos \delta}$$

where l stands for γS and δ for CS.

Greek Method :

We give below the Ptolemy's method in a slightly modified form¹. Let SHA be the triangle and γCE be the transversal ; then we have,

$$\frac{\sin SC}{\sin CH} \times \frac{\sin HE}{\sin EA} \times \frac{\sin A\gamma}{\sin \gamma S} = 1 \\ \text{or } \frac{\sin \delta}{\cos \delta} \times \frac{\sin 90^\circ}{\sin EA} \times \frac{\sin (90^\circ + l)}{\sin \gamma} = 1 \\ \therefore \sin EA = \frac{\sin \delta \times \sin (90^\circ + l)}{\cos \delta \times \sin l},$$

which is readily transformed into Bhāskara's equation. The originality of Bhāskara would be readily admitted.

Problem VI—

To find the Angle between the
Ecliptic and the Horizon

Indian Method :

(A) Āryabhaṭa's method. It consists of the following² steps :—

- (1) Determination of the orient point of ecliptic.
- (2) Finding the sine of its amplitude.

1. Manitius, *ibid*, Book I, pp. 104-06.

2. Āryabhaṭa, *Gola*, 33 : *Sūryasiddhānta*, V, 5-6.

- (3) Determination of the culminating point of the ecliptic from the hour-angle of the Sun.
- (4) Finding the declination of the culminating point of the ecliptic.

Having obtained the above elements, his rule can be followed thus :

In this Fig. 11 NZH is the meridian, HMEAN the horizon, CN'A the ecliptic. If N' be the nonagesimal or the highest point of the ecliptic, the altitude of N' is the inclination of the ecliptic to the horizon.

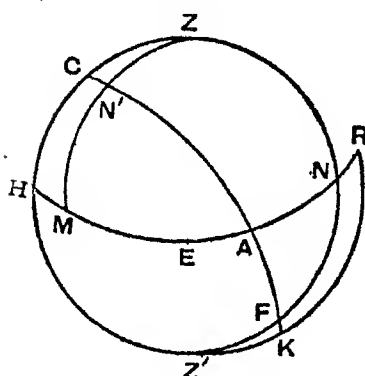


Fig. 11

Here HM=EA.

According to Āryabhaṭa,

$$R \sin CN' = \frac{R \sin CZ \times R \sin HM}{R}$$

$$\text{and } R \sin ZN' = \sqrt{(R \sin CZ)^2 - (R \sin CN')^2}$$

This is only an approximate rule. As expressed here,

$$R \sin ZN' = \frac{R \sin CZ \times R \cos HM}{R} \text{ approximately.}$$

$$= \frac{R \sin CZ \times R \cos HM \times R}{R \times R \cos CN'} \text{ accurately.}$$

$$= \frac{R \sin CZ \times R \cos HM}{R \cos CN'}.$$

(B) The method of Brahmagupta² :

Brahmagupta would also first determine the orient ecliptic

1. This correction was perhaps first noticed by Raṅganātha (1603 A. D.) in his commentary in the *Sūryasiddhānta*.

2. *BrSpSi*, V 3.

Let ZN'M be the vertical through N', meeting the horizon at M.

When the time is given, the longitudes of A and C can be found out, from which CZ the zenith distance of C and EA the amplitude of the orient ecliptic point can be determined.

$$SQ = SS' \times \frac{R \cos S'SQ}{R} = \frac{P \times R \sin ZS}{R} \times \frac{R \cos S'SQ}{R}$$

$$= \frac{P}{R} \sqrt{(R \sin ZS)^2 - (R \sin ZN')^2}$$

$$= \frac{P}{R^2} \times R \sin N'S \times R \cos ZN', \text{ where } N' \text{ is the nonagesimal}$$

Thus $R \cos S'SQ$ is seen to be

$$= \frac{R \sin N'S \times R \cos ZN'}{R \sin ZS}$$

The Indian method is fully described by Bhāskara in his '*Goladhyaṃya*. VIII, 12-25. The truth of the Indian rule for $R \cos S'SQ$ is easily seen from the spherical triangle $AN'S$ where A is the pole of the ecliptic.

Greek Method :

³Ptolemy takes SK and SL 90° each, along the vertical circle $ZSEK$ and the ecliptic $N'SA$. The great circle through K and L cuts the horizon at R which is the pole of the vertical circle. He takes SKL for the triangle and EAR for the transversal, then

$$\frac{\sin SE}{\sin EK} \times \frac{\sin KR}{\sin LR} \times \frac{\sin LA}{\sin AS} = 1$$

$$\text{or } \sin LR = \frac{\cos ZS \times \cos AS}{\sin ZS \times \sin AS}$$

$$\text{or } \cos S'SQ = \cot ZS \times \cot AS = \tan SE \times \cot AS.$$

The Indian and the Greek rules are altogether different both in form and method. There can, therefore, be no question of any connection between them.

Problem VIII :—

To convert the Celestial Longitude of a Heavenly Body into its Polar Longitude

If σ be the position of a (Fig.13), γK and σK are the celestial longitude and the celestial latitude, respectively; γM and σM are the polar longitude and polar latitude; γN and σV are the right ascension and declination of the star.

Indian Method :

All Indian astronomers attempt at finding MK which sub-

1. Āryabhaṭa, *Gola*, 34; *Pañcasiddhāntikā*, IX, 22 *BrSpSi*, XI, 23.
2. *BrSpSi*, V, 4-5; *Sūryasiddhānta*, V, 7-8 Bhāskara, *Grahagaṇita*, XII, 4.
3. Manilius, *ibid*, p. 119.

point A. Then he subtracts 90° from the longitude of A. Thus having the longitude of N', he next finds the part of the day elapsed of N'; from which by the time-altitude equation discussed above, he finds ZN'. This is of course more accurate than that of Āryabhaṭa. Bhāskara¹ here follows Brahmagupta.

Greek Method :

Let the ecliptic CN'A cut the lower half of the meridian at F. Ptolemy takes AK along the ecliptic $= 90^\circ$ and AR along the horizon $= 90^\circ$; then the great circle passing through R and K passes through the nadir Z'. Now take Z'FK for the triangle and ANR for the transversal, then by Menelaus's theorem,²

$$\frac{\sin FN}{\sin NZ'} \times \frac{\sin Z'R}{\sin RK} \times \frac{\sin KA}{\sin AF} = 1$$

$$\therefore \sin RK = \frac{\sin FN}{\sin AF} = \frac{\cos FZ'}{\sin AC} = \frac{\cos CZ}{\sin AC} = \frac{\sin CH}{\sin AC}$$

$$\text{or } \sin MN' = \frac{\sin CH}{\sin AC}.$$

Here Ptolemy's equation is simpler than that of Āryabhaṭa; hence they must be independent of each other.

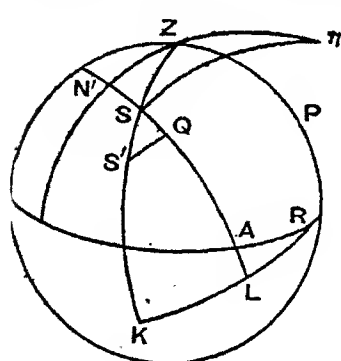


Fig. 12

Problem VII:—

To find the Angle made by the Vertical through any Point of the Ecliptic with the Latter

This problem is considered by Ptolemy but it is not considered separately in Indian Astronomy, but from the rule for parallax in longitude, the rule for its calculation can be deduced.

Indian Method :

In Fig. 12 S represents the true position of the Sun and S' the Sun's position as depressed by parallax. N'SA is the ecliptic. If from S', S'Q be drawn perpendicular to the ecliptic, then, if P is the horizontal parallax,

1. *Grahagaṇita*, XII, 3-4.

2. Manilius, *ibid.*, pp. 110-111.

$$SQ = SS' \times \frac{R \cos S'SQ}{R} = \frac{P \times R \sin ZS}{R} \times \frac{R \cos S'SQ}{R}$$

$$^1 = \frac{P}{R} \sqrt{(R \sin ZS)^2 - (R \sin ZN')^2}$$

$$^2 = \frac{P}{R^2} \times R \sin N'S \times R \cos ZN', \text{ where } N' \text{ is the nonagesimal.}$$

Thus $R \cos S'SQ$ is seen to be

$$= \frac{R \sin N'S \times R \cos ZN'}{R \sin ZS}$$

The Indian method is fully described by Bhāskara in his '*Goladhyaya*. VIII, 12-25. The truth of the Indian rule for $R \cos S'SQ$ is easily seen from the spherical triangle πZS , where π is the pole of the ecliptic.

Greek Method :

³Ptolemy takes SK and $SL = 90^\circ$ each, along the vertical circle $ZSEK$ and the ecliptic $N'SA$. The great circle through K and L cuts the horizon at R which is the pole of the vertical circle. He takes $\angle SKL$ for the triangle and $\angle EAR$ for the transversal, then

$$\frac{\sin SE}{\sin EK} \times \frac{\sin KR}{\sin LR} \times \frac{\sin LA}{\sin AS} = 1$$

$$\text{or } \sin LR = \frac{\cos ZS \times \cos AS}{\sin ZS \times \sin AS}$$

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All Indian astronomers attempt at finding MK which, sub-

1. Āryabhaṭa, *Gola*, 34; *Pañcasiddhāntikā*, IX, 22 *BrSpSi*, XI, 23.
2. *BrSpSi*, V, 4-5; *Sūryasiddhānta*, V, 7-8 Bhāskara, *Grahagaṇita*, XII, 4.
3. Manitius, *ibid*, p. 119.

tracted from, or added to, γK the celestial longitude, gives γM the polar longitude.

According to Āryabhata¹,

$$MK = \frac{\sigma K \times R \text{ vers } \gamma K \times R \sin \omega}{R^2}.$$

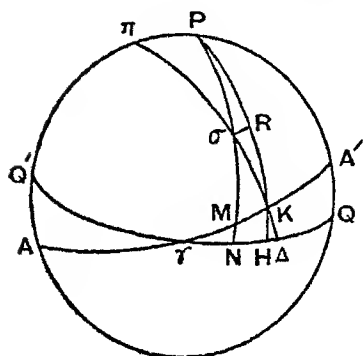


Fig- 13

$$NH = \frac{\sigma K \times R \sin (\gamma K + 90^\circ) \times R \sin \omega}{R}$$

If from σ , σR is drawn perpendicular to PKH , it is evident that

$$R \sin \sigma R = \frac{R \sin \sigma K \times R \sin \sigma KR}{R}.$$

According to Āryabhata and Brahmagupta, as explained before,

$$R \sin \sigma KR = \frac{R \sin (\gamma K + 90^\circ) \times R \sin \omega}{R}$$

Hence Brahmagupta intends that,

$$NH = \sigma R = \frac{\sigma K \times R \sin \sigma KR}{R}$$

which is rather a big assumption. He then directs the finding of the part of the ecliptic of which σR or NH is the projection on the equator thus approximately to MK .

Āryabhata, Brahmagupta³ and the modern *Sūryasiddhanta* take the declination $\sigma N = \sigma K + KH$ where σK is small. They do not consider the case where σK is large.

Bhāskara alone gives us fairly correct rules for this transformation of co-ordinates.

1. Āryabhata, *Gola*, 36.

2. *BrSpSi* X, 17.

3. *BrSpSi*, X, 15, *Sūryasiddhanta*, II, 58.

In order to find σN , he would multiply

σK by $\frac{R \cos \sigma KP}{R}$; according to him,

$$\sigma N = \frac{\sigma K \times R \cos \sigma KP}{R} + KH^1$$

This is a decided improvement on Brahmagupta's corresponding rule. The declination σN obtained would be very nearly accurate.

Having obtained σN , Bhāskara² then directs the finding of NH , thus,

$$NH = \frac{\sigma K \times R \sin \sigma KP}{R \cos \sigma N}$$

He then directs the finding of MK on the ecliptic of which NH is the projection by means of the times of rising of the signs of the zodiac on the equator.

Thus, the Indian methods show a beginning and development only. The Greek method as given by Ptolemy is mathematically accurate.

Greek Method³

To transform the celestial longitude and celestial latitude to right ascension and declination.

Let the great circle $\pi \sigma K$ meet the equator at Δ . Ptolemy would then from the given value of γK , find $\gamma \Delta$ and ΔK by using his tables for the rising of signs of the zodiac on the equator. He then takes $\pi P \sigma$ for the triangle and $\gamma N \Delta Q$ for the transversal. The Menelaus' Equation, then, is

$$\frac{\sin \pi Q}{\sin QP} \times \frac{\sin PN}{\sin N\sigma} \times \frac{\sin \sigma \Delta}{\sin \Delta \pi} = 1^2$$

Here $\pi Q = 90^\circ + \omega$, $QP = 90^\circ$, $PN = 90^\circ$; $\sigma \Delta = \sigma K + K \Delta$.

$\pi \Delta = 90^\circ + K \Delta$, whence $N\sigma$ is obtained.

He next takes PNQ for the triangle and $\pi \sigma \Delta$ for the transversal.

$$\therefore \frac{\sin P\pi}{\sin \pi Q} \times \frac{\sin Q\Delta}{\sin \Delta N} \times \frac{\sin N\sigma}{\sin \sigma P} = 1$$

Here $P\pi = \omega$, $\pi Q = 90^\circ + \omega$, $Q\Delta = 90^\circ - \gamma \Delta$.

Hence the above equation gives him ΔN . Now,

$$\gamma N = \gamma \Delta - \Delta N.$$

1. Bhāskara, *Grahaganita* XIII, 3.

2. Ibid. XIII, 4.

3. Manitius, Ibid, Vol. II, *Achtes Buch*, pp. 84-85.

It is almost needless to say that neither in the method nor in the rules is there any agreement between the Indian and Greek spherical astronomy in the solution of this problem.

Kaye's view¹

As to Kaye, it appears that he has not been able to find a method in the translation of the *Sūryasiddhānta* by Burgess. The figures of his paper referred to before do not show the "Akṣakṣetras" even in their projections on the meridian plane. He refers to Braunmühl's *History of Trigonometry* but does not appear to have been able to follow him in his "*Methode der indischen Trigonometrie*." Kaye, however, is not slow in belittling Indian trigonometry when he says :—The Indian astronomers employed the sine function principally and the versed sine occasionally ; they never employed the tangent function; and generally, but not always, preferred to employ the sine of the complementary angle rather than the cosine functions.'

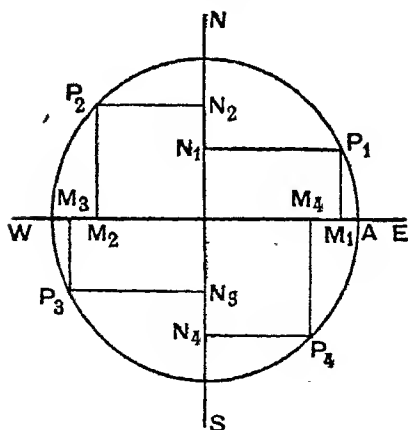


Fig. 14

In (Fig. 14), of the arc AP_1 , P_1M_1 is the "sine" and P_1N_1 is the "cosine" of AP_1 , P_2M_2 is the "sine" and P_2N_2 is the "cosine"; of AP_3 , P_3M_3 is the "sine" and P_3N_3 is the "cosine"; etc. It is evident that a better definition of these functions was never given.

We have thus seen that some of the solutions of Āryabhaṭa

1. J. A. S. B., N. S., XV, p. 154.

2. तस्य बिन्दोः ग्रन्थ-परायाश्च यदन्तरं सौदोज्या ।

बिन्दोर्यान्वोत्तरायाश्च यदन्तरं सा कोटिज्या ॥

—(Bhāskara, *Grahagaṇita*, commentary. II, 88-21

are imperfect, of Brahmagupta the solutions are more accurate, while those of Bhāskara are generally mathematically correct. The date of the scientific ancient Indian Astronomy is indeed 499 A. D., while that of the *Syntaxis* is about 150 A. D. It is by these shortcomings and differences in the methods, new ideas (e.g., the idea of the differential calculus)* and the like, that we can safely say that Indian Astronomy in its scientific form, although of a later date than the "*Syntaxis*" of Ptolemy, is original and not borrowed from foreign source. There is evidence that some crude form of Greek astronomy was transmitted to India and went by the name of the "*Romaka*" or the "*Paulisa*" Siddhānta, prior to the time of Āryabhaṭa but our great Indian astronomers, Āryabhaṭa with his pupils, Varāha-mihira and Brahmagupta, had to construct a new science altogether.

(This Chapter is almost a reproduction of the paper by P. C. Sengupta, as acknowledged earlier).

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Reference

P.C. Sengupta : The *Khaṇḍakhādyaka*, 1934

CHAPTER VII

Epicyclic Theory of Ancient Indians

We shall give here some details of the Indian concepts regarding the motion of planets or wandering bodies among the stars. The *Vedāṅga Jyotiṣa* (1400 B. C. or earlier) does not speak of this. A comparison of the astronomical constants of the Greek and the ancient Indian systems, points unmistakably to the conclusion that the Indian constants as determined by Āryabhaṭa I and his successors, are almost in all cases different from those of Greeks. Indian astronomers were highly original in their concepts and treatment. The originality of Āryabhaṭa I and other astronomers would be seen from what we are describing below.

Apparent Motions of the Sun and Moon

We have the following passages from Āryabhaṭa :

All planets move in eccentrics to their orbits at the mean rates of angular motion, in the direction of the signs of the zodiac from their apogees (or aphelia) and in the opposite directions from their *Śighroccas*.

The eccentric circles of planets are equal to their concentrics and the centre of the eccentric is removed from the centre of the Earth.

The distance between the centre of the Earth and the centre of the eccentric is equal to the radius of the planet's epicycle; on the circumference (whether of the epicycle or of the eccentric) the planet undoubtedly moves with the mean motion.

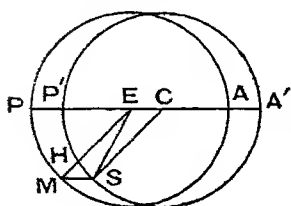


Fig. 15

Here the central idea was that undoubtedly planets moved uniformly in circles round the Earth; if the motion appeared to be variable, it was due to the fact that the centres of such circle (i. e. the concentric circles) did not coincide with the centre of the Earth.

Let E represent the centre of the Earth (Fig. 15), APM the Sun's circular orbit or concentric; let A and P be the apogee and the perigee respectively. From EA, cut off EC equal to the radius of the Sun's epicycle. With centre C and radius equal to EA describe the eccentric A'P'S cutting AP and AP produced at P' and A'. Here A' and P' are the real apogee and perigee of the Sun's orbit. Let PM and P'S be any two equal arcs measured from P and P'.

The idea is that the mean planet M and the apparent Sun S move simultaneously from P and P' in the counterclockwise direction along the concentric and the eccentric circles. They move with the same angular motion and arrive simultaneously at M and S.

Here EM and CS are parallel and equal, hence MS is also equal and parallel to EC. Let SH be drawn perpendicular to EM.

The angle PEM is the mean anomaly and the angle P'ES the true anomaly; the angle SEM is the equation of the centre, is readily seen to be plus (+) from P' to A' and minus (-) from A' to P'. Thus as regards the character of the equation, the eccentric circle is quite right. We now turn to examine how far it is true as to the amount.

Let the angle SEM denoted by E and the angle $\angle PEM = \angle P'CS = \theta$; $EP = CP' = a$; $EC = MS = p$, then

$$\tan E = \frac{SH}{HE} = \frac{p \sin \theta}{a - p \cos \theta}$$

$$\therefore E = \frac{p}{a} \sin \theta - \frac{p^2}{2a^2} \sin 2\theta + \frac{p^3}{3a^3} \sin 3\theta \dots\dots\dots$$

Now the true value of E in elliptic motion is given by

$$E = \left(2e - \frac{e^3}{4} \right) \sin \theta + \frac{5}{4} e^2 \sin 2\theta + \frac{13e^3}{12} \sin 3\theta^* \dots$$

If we now put $\frac{p}{a} = 2e - \frac{e^3}{4}$, as a first approximation $\frac{p}{a} = 2e$.

Hence $\frac{p^3}{2a^3} = 2e^3$, which is greater than $\frac{5}{4} e^2$ by $\frac{3}{4} e^2$. In the case of the Sun if the value of p be correctly taken the error in the coefficient of the second term becomes +3'; similarly in the case of the Moon, the corresponding error becomes +8'.

*Godfray's Astronomy, p. 149.

Again if $\frac{p}{a}=2e$, what is the centre of the eccentric circle is the empty focus of the ellipse or that the ancient astronomers practically took the planets to be moving with uniform angular motion round the empty focus. This was not a bad approximation.

Also $ES=r=EH$ approximately,

$$\therefore r=a \left(1 - \frac{p}{a} \cos \theta \right)$$

but in the elliptic motion

$$r=a(1-e \cos \theta)^*.$$

Hence the error is not very considerable here also.

This is the way in which the ancient astronomers, both Greek and Hindu, sought to explain the inequalities in the motion of the Sun and the Moon. In the case of the Moon, these astronomers took the coefficient $2e - \frac{e^3}{4} = 300'$ nearly; the modern value is $377'$ nearly. The reason for this has been pointed out to be that the Moon was observed correctly only at times of eclipses. At the eclipses of sygygies, the evection term of the Moon's equation diminishes (numerically) the principal ecliptic term by about $76'$.

We have thus far explained the idea of planetary motion of the ancients under the eccentric circle construction. The same, however, is explained under the epicyclic construction.

Let AMP be the circular orbit of the Sun, having E the centre of the earth for the centre. (Fig. 16)

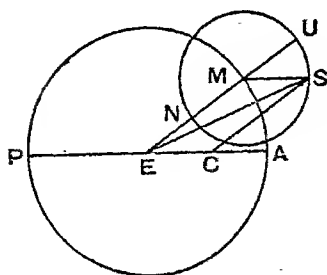


Fig. 16

Let the diameter AEP be the apse line. A the apogee and P the perigee. Let M be the mean position of the Sun in the orbit. With M as the centre, describe the epicycle UNS. Let EM cut the epicycle at N and U. Now the construction for finding S the apparent Sun is thus given:—

Make $\angle UMS = \angle MEA$, the arc US is measured clockwise whereas the arc A to M is measured counterclockwise.

From this construction MS is parallel to EA. If EC be measured equal to MS, the radius of the epicycle, along EA to—

* Godfray's *Astronomy*, p. 149.

wards the apogee, then CS is a constant length and C is a fixed point. Hence the locus of S is an equal circle with the centre at C . Thus both the eccentric, and the epicycle and the concentric combined, led to the same position.

It was thus usual to explain the planetary motion under both the assumed constructions; and both gave the position for a planet. The eccentric circle construction appears to be the earlier in the history of astronomy and the latter was later. If the former construction can be traced to Apollonius of Perga who did so much to develop the "conic sections" as science, the reason why he preferred the eccentric circle to the ellipse, appears to be that either that this planetary construction was always deep-rooted in the minds of men or that he was carried by the idea that "the circle was the most perfect curve." We are inclined to the view that the eccentric circle idea was transmitted from Babylonia to Greece. We now pass on to consider the Indian construction for the position of superior and inferior planets.

Superior Planets

With regard to the five planets, Mercury, Venus, Mars, Jupiter and Saturn, the Indian astronomers give only one construction for finding the apparent geocentric position. Each of these "star planets" is conceived as having twofold planetary inequalities: (i) the inequality of apsis, (ii) the inequality of the *śighra*. With regard to the superior planets, the *śighra* apogee or the *śighrocca* coincided with the mean position of the Sun. As Varāhamihira observed, of the other planets beginning with Mars, the Sun is the so-called *śighra*. (*PSi*. XVII. 1)

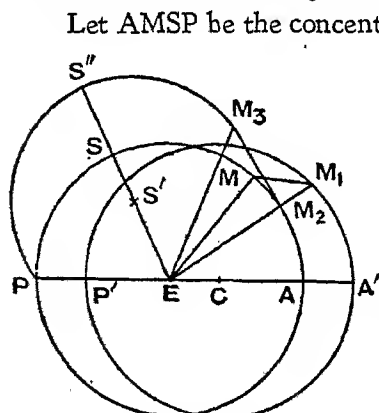


Fig. 17

Let $AMSP$ be the concentric of which the centre E is the same as that of the earth (Fig. 17); $A'M_1P'$ the eccentric circle of apsis of a superior planet, of which the centre is C ; A, M, S, P be respectively the apogee, the Mars planet, the direction of the *śighra* and the perigee of the concentric; A', M_1, P' be the apogee, the planet as corrected by the equation of apsis, P' the perigee in the eccentric. The arc

$AM = \text{arc } A'M_1$; MM_1 is parallel and equal to EC . As used before, both the concentric and the eccentric are of the same radius.

Here the mean planet M in the concentric is taken to be deflected to M_1 due to the true motion in the eccentric circle. Join EM_1 cutting the concentric at M_2 . Now let ES be joined and let S' be taken along ES , such that

$$\frac{ES'}{ES} = \frac{\text{Sighra periphery of the planet in degrees}}{360} \\ = \frac{\text{Sun's mean distance from the Earth}}{\text{Planets mean distance from the Sun or the Earth;}}$$

ES' thus determined is called the radius of the *sighra* epicycle of the superior planet.

With S' as the centre and the radius equal to ES or EA describe another circle which is called the *sighra* eccentric cutting ES produced at S'' . Now measure the arc $S''M_2$ in the concentric $= SM_2$ in the concentric. The apparent superior planet is seen in the direction EM_2 from the Earth. This is the construction used in Hindu astronomy calculating the geocentric longitude of any star planet.

It is evident in the case of a superior planet that the eccentric having S' for the centre and whose radius $= EA = R$ the standard radius for any circular orbit, is the mean orbit of the planet and S' the mean position of the Sun. In other words, in the case of a superior planet, the *sighra* eccentric represents the mean orbit round the Sun. If the parallelogram $CES'C'$ be constructed, then an equal circle described with C' as the centre is the apparent eccentric orbit of the superior planet.

In the actual method of calculating the geocentric longitude of a "star planet" there are four operations given, the first two of which have the effect of changing the arc MA or rather the point A . The last two operations relate to the two displacements MM_1 and M_2M_3 . We have here followed solely the construction of the eccentric circles; the same geocentric position of a superior planet could be equally well obtained by the epicyclic construction. In describing the constructions for finding the position, of an inferior planet we shall follow the epicyclic construction only

Inferior Planets

Let E be the centre of the Earth (Fig. 18), AMS the orbit of

CHAPTER VIII

Brahmagupta and Arithmetic

Scope of Gaṇita

The word *Gaṇita* means the science of calculation. The term occurs in the *Vedāṅga Jyauṭiṣa* (c. 1200 B. C.):

Just as the crest is to the peacocks, and just as the head-gem is to the snakes, so the *Gaṇita* among the *Vedāṅga Śāstras* stands at the head.¹ (VJ. 4)

In the ancient Buddhistic literature, we find mention of three classes of *gaṇita* : (i) *mudrā* (finger arithmetic), (ii) *gaṇanā* (mental arithmetic), and (iii) *saṃkhyāna* (higher arithmetic in general). In the *Brahmasphuṭasiddhānta*, Brahmagupta uses the word *gaṇita* in the sense of entire calculations. His *gaṇitadhyāya* (Chapter XII) includes ;

(i) *Miśra* (mixtures), (ii) *Śreṇhī* (series), (iii) *Kṣetra* (plane figures), (iv) *Vṛtta-kṣetra* (circles), (v) *Khāta* (excavations), (vi) *Citi* (piles of bricks), (vii) *Krākacika* (sawn pieces of timber), (viii) *Rāsi* (heaps or mounds of grain), and (ix) *Chāyā* (shadow).

Brahmagupta also uses the term *Dhūlikarma* (literally meaning "aspwork") for higher mathematics :

The one learned man who knows the *dhūlikarma* or the science of mathematics as propounded by Brahmagupta would far excel them in learning who are taught the calculations according to Āryabhaṭa, Viṣṇucandra and others.²

In these ten chapters of the *Brahmasiddhānta* has been given the *dhūlikarma* or the science of entire calculations

1. यथा शिखा मयूराणां नागानां मणयो यथा ।

तद् वद् वेदाङ्ग-शास्त्राणां गणितं मूर्धनि स्थितम् ॥

VJ. 4.

2. नावायौ ज्ञातेरपि तन्त्रैरार्यभट्टविष्णुचन्द्रार्थैः ।

यो ब्रह्म धूलिकर्मविदाचार्यत्वं भवति तस्य ॥

—BrSpSi. X. 62.

which is faultless.¹

This science of *dhulikarma* has not been imparted by great teachers for blasphemy. One who would be using it for this purpose would lose all good name.²

Brahmagupta uses the term *ganita* only for those calculations which are of arithmetical in nature. The science of algebra, the foundations of which was laid by Āryabhaṭa I, was named as *kuttaka* or *kuttākāra* by Āryabhaṭa, and in the *Brāhmasphuṭa-siddhānta* also it is separately dealt with under *Kuṭṭadhyāya* or *kuṭṭakādhyāya* (Chapter XVIII). Later on the term *bījaganita* was specifically given to the science of algebra.

The *Kuṭṭadhyāya* of the *Brāhmasphuṭasiddhānta* deals with the (i) concept of *kuṭṭaka* (pulveriser), addition of positive and negative as well as zero quantities, equations in one unknown (*eka-varṇa samikarāṇa*), equations in several unknowns (*aneka-varṇa samikarāṇa*), equations involving products of unknowns (*bhāvita*) and quadratic equations (*varga-prakṛtiḥ*) (Chapter XVIII of the *Brāhmasphuṭasiddhānta*).

Āryabhaṭa, Bhāskara and Brahmagupta use Place Value Notations.

In Europe the first definite traces of the place-value numerals are found in the tenth and eleventh centuries, but the numerals came into general use in mathematical text books only in the seventeenth century. In India, however, Āryabhaṭa I (499), Bhāskara I (522), Lalla (c. 598) and Brahmagupta (628) all use the place value numerals. There is no trace of any other system in their works. Perhaps in this country we had the place value system as early as 200 B.C. if not earlier. The use of a symbol for zero is found in Piṅgala's *Chandaḥ Sūtra* (perhaps of 200 B.C.). In literature, we have an indication of the place value from about 100 B.C. and later in the Purāṇas from the second to the fourth century A.D. The *Bakhaṣālī Manuscript* (perhaps of 200 A.D.) uses the place-value notations. The earliest use of the place value principle with the letter numerals

1. ग्रहयोगेन ग्रहयुतिरार्यात्रिशतियुताष्टसप्तत्या ।

अध्वार्हदेशमिधुलिकर्म बोच्चेर्विना ब्रह्म ॥

—BrSpSi. X. 66.

2. गुरुणा न धूलिकर्म प्रतिकंचुककारिणे प्रदातव्यम् ।

दत्तं सुष्ठुप्रसाशं कुरुते प्रतिकंचुकं यस्य ॥

—BrSpSi. X. 67

is found in the works of Bhāskara I about the beginning of the sixth century A.D. Thus for 3179, the expressive words are *Navādrirūpāgni*¹ (*nava* 9, *adri* 7, *rupa* 1 and *agni* 3). Similarly in the *Brāhmasphuṭasiddhānta*, for a large number like 2296828522, the expressive terms are *DVIYAMAŚARĀṢṬAPAKṢAVASŪRA-SANAVADVİYAMĀḤ* (*Dviyama* two twos 22, *Śara* 5, *aṣṭa* 8, *pakṣa* 2, *vasū* 8, *rasa* 6, *nava* 9, *dviyamāḥ* 22).² Such usages are to be found in all works, which clearly state the place value concept was popular as a routine. From India, this system reached Arabia. During the reign of the Khalif Al-Mansur (753-774 A.D.) there came embassies from Sindh to Baghdad, and among them were scholars, who brought along with them several works on mathematics including the *Brāhmasphuṭasiddhānta* and the *Khaṇḍakhādya* of Brahmagupta. With the help of these scholars, Al-fazari, perhaps also Yakub ibn Tarik, translated them into Arabic. Both works were largely used and exercised great influence on Arab mathematics. It was on that occasion that the Arabs first became acquainted with a scientific system of astronomy. It is acceptable to all writers on the subject that it was at that time that the Hindu numerals were first definitely introduced amongst the Arabs. Arabs at first adopted the *ghobar* form of numerals which they had already obtained (but without zero) from the Alexandrians or from the Syrians. This they continued for about two centuries, but since they were not suited to their right-to-left script, they gave them up and adopted the more convenient ones. For a detailed discussion on how numerals went to the west from India and spread in Europe one is referred to this discussion in the *History of Hindu Mathematics*. Part I by Datta and Singh (1935, Single volume Edition, 1962, pp. 83-104). It is remarkable that Brahmagupta's works like the *Brāhmasphuṭasiddhānta* and the *Khaṇḍakhādya* became instrumental in the spread of the place-value notation in the neighbouring countries of the Middle East, and from their this system spread into Europe.

Operations and Determinations in Pāṭigaṇita

The word *Pāṭigaṇita* is a compound formed from the words *pāṭi*, meaning 'board', and *gaṇita*, meaning 'science of calculation',

1. *MBh.* 1. 4;

2. *BrSpSi* 1-16.

hence it means the science of calculation which requires the uses of writing material (the board). The word *pāṭi* is not Sanskrit (it originated in the non-Sanskrit literature in India); the oldest term in Sanskrit for the board is *Phalaka* or *paṭṭa*. However this term got currency in the Sanskrit literature also about the beginning of the seventh century. Brahmagupta does not use the term *pāṭiganita*: he favours the use of the term *dhūlikarma* or writing figures on dust spread on a board or on the ground. The word *pāṭiganita* was translated into Arabic as *ilm-hisab-al-takht* (calculation on board) and the word *dhūlikarma* as *hisab-al-ghobār* (calculation on dust).

Brahmagupta, in the very first verse in the Chapter XII (*Gaṇitādhyāya*) refers to twenty operations (*parikarma*) and eight determinations :

He who distinctly and severally knows the twenty logistics, addition etc., and the eight determinations (*vyavahāra*) including (measurement by) shadow is a *gaṇaka* (mathematician).¹

The commentators have given the list of these logistics (*parikarma*) and determinations* (*vyavahāra*) as follows;

(A) *Parikarma* or logistics

1. Saṁkalitam (addition)
2. Vyavakalitam (subtraction)
3. Gaṇanam (multiplication)
4. Bhāgaḥārah (division)
5. Vargaḥ (square)
6. Vargamūlam (square-root)
7. Ghaṇaḥ (cube)
8. Ghaṇamūlam (cube root)
9. 13. Five standard forms of fractions (Pañca-jāti)
14. Trairāśikam (the rule of three)
15. Vysta-trairāśikam (the inverse rule of three)
16. Pañca-rāśikam (the rule of five)
17. Sapta-rāśikam (the rule of seven)
18. Nava-rāśikam (the rule of nine)

1. परिक्रमं विरतिं यः संकलितयां पृथक् विजानाति ।

अथैव व्यवहारान् क्षयान्तान् भवति गणकः सः ॥

19. Ekādaśa-rāśikam (the rule of eleven)
20. Bhāṇḍa-pratibhāṇḍam (barter and exchange)

(B) *Vyavahāra* or determinations

1. Miśrakāḥ (mixture)
2. Średhī (progression or series)
3. Kṣetram (plane figures)
4. Khātam (excavation)
5. Citih (stock)
6. Krākacikāḥ (saw)
7. Rāśih (mound)
8. Chāyā (shadow)

Of the operations enlisted here, the first eight have been considered fundamental by later writers as Mahāvira. The operations of duplation and mediation (doubling and halving) were considered fundamental by Arabs, Greeks and Egyptians; since they were not familiar with the place-value system.

Mathematics in this country developed as an aid to astronomy, and therefore, for the first time we find Āryabhaṭa (499 A.D.) in his *Āryabhaṭīya* describing as a special section (*Gaṇitapāda*). Brahmagupta (628 A.D.) also followed Āryabhaṭa in this respect and gave the science of calculation (*gaṇita*) a special place in his treatise on astronomy. The *Siddhānta* treatises, earlier than those of Āryabhaṭa and Brahmagupta do not contain a chapter exclusively devoted to *gaṇita* (the *Sūrya-Siddhānta* and the *Siddhāntas* of *Vasiṣṭha*, *Pitāmaha* and *Romaka* are thus without *gaṇita* chapters). Later on Bhāskara I and Lalla also did not include *gaṇita* as a section or chapter in their treatises. It is said, however, that Lalla wrote a separate treatise on *Pāṭiganita*.

It may further be remarked here that Āryabhaṭa I gives the rules for finding the square and cube-roots only whilst Brahmagupta gives the cube-root rule only (*BrSpSi*. XII. 7).

Multiplication

Undoubtedly the common Indian name 'multiplication' is 'guṇana', this term occurs in the Vedic literature also. The other terms for this logistics are *hanana*, *radha*, *kṣaya* etc., which all mean 'killing' or 'destroying.' The synonyms of 'hanana' (killing) for multiplication have been used by Āryabhaṭa I (499). Brahmagupta (628), Śrīdhara (c.750) and later writers, and these terms

also occur in the Bakhaśālī Manuscript.

Āryabhaṭa I does not mention the everyday methods of multiplication in his *Āryabhaṭīya* probably because they were too elementary to be included in a Siddhānta work. Brahmagupta, however, in a supplement to the section on mathematics in his *Siddhānta*, gives the names of some methods with very brief descriptions of the processes:—

The multiplicand repeated, as in *gomūtrikā* as often as there are digits in the multiplier, is severally multiplied by them and (the results) added according to places; this gives the product. Or the multiplicand is repeated as many times as there are component parts in the multiplier.¹

(the word *bheda* occurring in the verse has been translated as “integrant portions” by Colebrooke p. 319. Again by the term *bheda* are meant portions which added together make the whole, or aliquot parts which multiplied together make the entire quantity.

The multiplicand is multiplied by the sum or the difference of the multiplier and an assumed quantity and, from the result the product of the assumed quantity and the multiplicand is subtracted or added.²

(Colebrooke thinks that this is a method to obtain the true product when the multiplier has been taken to be too great or too small by mistake.³ Datta and Singh think, however, that this is not correct.⁴

Thus Brahmagupta mentions four methods of multiplication: (i) *gomūtrikā*, (ii) *khaṇḍa*, (iii) *bheda*, and (iv) *iṣṭa*. The common and the well known method of *kapāṭa-sandhi* has been omitted by him.

1. गुणकारखण्डतुल्यो गुण्यौ गोमूत्रिकाकृतो गुणितः ।

सहितः प्रत्युत्पन्नो गुणकारकमेदतुल्यो वा ॥

—BrSpSi XII. 55

2. गुण्यो राशिगुणकारराशिनेष्टाधिकोनकेन गुणः ।

गुण्योष्टव्यो न युतो गुणकेऽभ्यधिकोनके कार्यः ॥

—BrSpSi. XII. 56

3. Colebrooke, T. H., *Hindu Algebra*, p. 320.

4. Datta, B. and Singh, A. N., *History of Hindu Mathematics Pt. I (Arithmetic)*, p. 135 (1962).

(i) *Gomūtrika*-method or zig-zag method. The word *gomūtrikā* means "similar to the course of cow's urine", hence "zigzag". This method in all essentials is the same as the *sthāna-khaṇḍa* method. The following illustration is based on the commentary of Pṛthūdaka Svāmī :

Example : To multiply 1223 by 235.

The numbers are written thus :

$$\begin{array}{r} 2 \quad 1223 \\ 3 \quad 1223 \\ 5 \quad 1223 \end{array}$$

The first line of figures is then multiplied by 2, the process beginning at units place, thus : $2 \times 3 = 6$; 3 is rubbed out and 6 substituted in its place, and so on. After all the horizontal lines have been multiplied by the corresponding numbers on the left in the vertical line, the numbers on the *pāṇi* stand thus :

$$\begin{array}{r} 2446 \\ 3669 \\ 6115 \\ \hline 287405 \end{array}$$

after being added together as in the present method.

The *sthāna-khaṇḍa* and the *gomūtrikā* methods resemble modern plan of multiplication most closely.

(ii) *Khaṇḍa* Method or Parts Multiplication Method : Since the days of Brahmagupta, this method of multiplication also became very popular. We have two methods under this head :

(i) The multiplier is broken up into two or more parts whose sum is equal to it. The multiplicand is then multiplied severally by these and the results added.

To take an example :

$$\begin{aligned} 13 \times 158 &= (6+7) \times 158 = (6 \times 158) + (7 \times 158) \\ &= 948 + 1106 \\ &= 2054 \end{aligned}$$

(ii) The multiplier is broken up into two or more aliquot parts. The multiplicand is then multiplied by one of these, the resulting product by the second and so on till all the parts are exhausted. The ultimate product is the result.

Thus for example :

$$\begin{aligned} 96 \times 237 &= (4 \times 4 \times 6) \times 237 \\ &= (4 \times 237) \times 4 \times 6 = 948 \times 4 \times 6 \\ &= (4 \times 948) \times 6 = 3792 \times 6 \\ &= 22752 \end{aligned}$$

These methods of multiplication are found among the Arabs and the Italians, having obtained from people of India. They were known as the "Scapezzo" and "Repiego" methods respectively amongst Italians.

(iii) *Iṣṭa-guṇana* Method or the Algebraic Method.

We have already quoted the relevant verse from the *Brahmasphuṭa-siddhānta* in this connection; (XII. 56) :

The multiplicand is multiplied by the sum or the difference of the multiplier and an assumed quantity and from the result the product of the assumed quantity and the multiplier is subtracted or added.¹

This method is of two kinds according as we (i) add or (b) subtract an assumed number. The assumed number is so chosen as to give two numbers with which multiplication will be easier than with the original multiplier. The two ways are illustrated below :

$$(i) 93 \times 13 = (93 + 7) \times 13 - 7 \times 13 = 1300 - 91 = 1209.$$

$$(ii) 93 \times 13 = (90 + 3)13 = 90 \times 13 + 3 \times 13 = 1170 + 39 = 1209$$

This method was in use among the Arabs and in Europe, obviously having gone out from this country.

This process has been regarded as an inverse of multiplication. The terms used for this operation are *bhāgahāra*, *bhājana*, *haraṇa*, *chedana*, etc., all these terms more or less carrying the sense "to break into parts", "to divide" etc., excepting "*haraṇa*" which denotes "to take away". This term shows the relation of division to the operation of subtraction. The dividend is termed as *bhājya*, *hārya* etc., the divisor is known as

1. गुरवो राशिगुणकारराशिनेष्टाधिकोनकेन गुणः ।

गुण्येष्टवधो न युतो गुणकेऽभ्यधिकोनके कार्यः ॥

bhājaka, *bhāgaḥara* or simply *hara*; quotient is known as *labdhi* or *labdha* (or “what is obtained”).

India never regarded this operation as a difficult one; in Europe, this operation was regarded as a tedious one till the 15th century or so. Division was such a common operation that Āryabhaṭa did not regard it as worth being included in his treatise. But since he has given the methods of extracting square-roots and cube-roots, which obviously depend on division, we conclude that the method of division was known to him. Most *Siddhānta* writers have followed Āryabhaṭa I in omitting this operation from their texts, this being regarded too elementary to be included. Brahmagupta does not give details of this operation. The later treatises on Arithmetic as Śrīdhara's *Trisatikā* and the *Pāṇiganita* (I.20) and Āryabhaṭa II (c.950 A.D.) have given the details of this operation.

Square

The Sanskrit term for square is *varga* or *kṛti* (*varga* literally means “rows” or “troops” of similar things). In mathematics, it usually means the square power and also the square figure or its area. Thus we find in the *Āryabhaṭīya* :

A square figure of four equal sides (and the number representing its area) are called *varga*. The product of the two equal quantities is also *varga*¹.

The term *kṛti* means “doing”, “making” or “action”. It carries with it the idea of specific performance probably the graphical representation.

For the first time we have a definite rule for squaring in the writings of Brahmagupta. But it does not mean that prior to him it was not known. It must have been known to Āryabhaṭa I since he has given the square-root method.

Brahmagupta gives his method of squaring briefly as follows :

Combining the product, twice the digit in the less (lowest) place into the several others (digits) with its (i.e. of the digit in the lowest place) square (repeatedly) gives the square.²

1. वर्गस्तमन्तुरश्रः फलञ्च सहशद्वयस्य संवर्गः ।

—Ārya. II. 3.

2. राशेरूनं द्विगुणं बहुतरगुणमनकृतियुतं वर्गः ।

—BrSpSi. XII. 63.

The method has been more clearly enunciated by Mahāvīra (850 A.D.) in the *Gaṇitasārasaṅgraha* :

Having squared the last (digit), multiply the rest by the digits by twice the last, (which) is moved forward (by one place). Then moving the remaining digits continue the same operation (process), This gives the square.¹

Brahmagupta's method of squaring is shown by the following example :

To square 125.

The number is written down

125

The square of the digit in the last place, i. e., $5^2=25$ is set over it thus :

25

125

Then, $2 \times 5=10$ is placed below the other digits, and 5 is rubbed out, thus :

25

12

10

Multiplying by 10 the rest of the digits, i.e., 12 and setting the product over them (the digits), we have.

1225

12

10

Then rubbing out 10 which is not required and moving the rest of the digits, i. e. 12 we, have

1225

12

Thus one round of operations is completed.

Again as before, setting the square of 2 above it and $2 \times 2=4$ below 1, we have

1625

1

4

1. GSS. P. 12.

Multiplying the remaining digit 1 by 4, and setting the product above it, we have

$$5625$$

1

Then moving the remaining digit 1, we obtain

$$5625$$

1

Thus the second round of operations is completed.

Next setting the square of 1 above it the process is completed for there are no remaining figures, and the result stands thus :

$$15625$$

Algebraic Method of Squaring

Brahmagupta in his *Brāhmasphuṭasiddhānta* gives a minor method of squaring thus :

The product of the sum and the difference of the number (to be squared) and an assumed number plus the square of the assumed number give square¹.

This may be represented by the following identity :

$$n^2 = (n-a)(n+a) + a^2$$

This identity has been used for squaring by most of the Indian mathematicians. Thus

$$15^2 = (15-5)(15+5) + 5^2 = 225$$

We are not giving here other identities which have been used by latter mathematicians of India in getting the squares of numbers; for example, when Mahāvīra says :

The sum of the squares of the two or more portions of the number together with their products each with the others multiplied by two gives the square² :

he obviously refers to the identity

$$(a+b+c+\dots)^2 = a^2 + b^2 + c^2 + \dots + 2ab + \dots$$

Cube

The Sanskrit term for cube is *ghana*. It when used in the geometrical sense also means the solid cube. In the arithmetical sense, it means the continued product of the same number taken three times. Thus we have the definition in the *Ārya-*

1. राशेरिष्ट्युत्तोलान्द्वयः कृतिर्वैकृतियुतः ।

2. GSS. p. 13.

bhaṭṭya :

The continued product of three equals and also the solid having twelve (equal) edges are called *ghana*.¹

A method of cubing applicable to numbers written in the decimal place-value notation, has been in use in this country from before the 5th century A.D. Āryabhaṭa I (499 A.D.) had the familiarity with this method; he, however, does not give the method of cubing in his treatise, though he describes the inverse process of extracting the cube-root.

Brahmagupta gives the method of cubing in the following verse :

Set down the cube of the last (*antya*); then place at the next place from it, thrice the square of the last multiplied by the succeeding; then place at the next place thrice the square of the succeeding multiplied by the last, and (at the next place) the cube of the succeeding. This gives the cube.²

The rule may be illustrated by an example.

Example : To cube 1357.

The given number has four places, i.e., four portions. First we take the last digit 1 and the succeeding digit 3, i.e. 13 and apply the method of cubing thus :

- | | |
|---|----------------------------------|
| (i) Cube of the last (1^3) | = 1 |
| (ii) Thrice the square of the last (3.1^2) multiplied by the succeeding (3) gives ($3.3.1^2$) | = 9 (placing at the next place) |
| (iii) Thrice the square of the succeeding, multiplied by the last gives ($3.3^2.1$) | = 27 (placing at the next place) |
| (iv) Cube of the succeeding (3^3) | = 27 (placing at the next place) |

Thus 13^3 is the sum

2197

1. सदृशवर्तुको घनस्तथा द्वादशाग्रस्यात् ॥

—Ārya, II. 3.

2. स्थानोन्त्यवर्गोन्त्यवर्गस्त्रिगुणोत्तरसंयुगा च तत्प्रथमान् ।

उत्तरवर्गस्त्रिगुणा त्रिगुणा चोत्तर घनश्च घनः ।

—BrSpSi. XII, 6.

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| (iv) Cube of the succeeding (3^3) | = 27 (placing at the next place) |

Thus 13^3 is the sum

2197

1. सप्तशतसंको धनस्तथा द्वादशाग्रस्यात् ॥

—Ārya, II. 3.

2. स्वाय्योऽन्यधनोऽन्यकृतिस्त्रिगुणोत्तरसंयुगा च तत्प्रथमान् ।

उत्तरकृतिस्तृगुणा त्रिगुणा चोत्तर धनश्च धनः ।

—BrSpSi. XII, 6.

After this we take the next figure, 5, i.e., the number 135, and in this consider 13 as the last and 5 as the succeeding. Then the method proceeds thus :

- (i) The cube of the last
(13³) as already obtained = 2197
- (ii) Thrice the square of the
last multiplied by the
succeeding, i.e. $3 \cdot 13^2 \cdot 5$ = 2535 (placing at the
next place)
- (iii) Thrice the square of the
succeeding multiplied
by the last, i.e. $3 \cdot 5^2 \cdot 13$ = 975 (placing at the
next place)
- (iv) Cube of the succeeding,
i.e. 5^3 = 125 (placing at the
next place)

Thus 135^3 is the sum 2460375

Now the remaining figure 7 is taken, so that the number is 1357, of which 135 is the last and 7 the succeeding. The method proceeds thus :

- (i) Cube of the last, i.e.
(135³) as already
obtained = 2460375
- (ii) Thrice the square of
the last into the succee-
ding, i.e. $3 \cdot (135)^2 \cdot 7$ = 382725 (placing at the
next place)
- (iii) Thrice the square of
the succeeding into the
last, i.e. $3 \cdot 7^2 \cdot 135$ = 19845 (placing at the
next place)
- (iv) Cube of the succeeding
i.e. 7^3 = 343 (placing at the
next place)

Thus $(1357)^3$ is the sum 2498846293

Evidently these methods of cubing are based on the identity:

$$(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$$

and keeping in mind the place values of numerals in a given

number (this accounts for keeping the results of each of the four operations at the next place).

Square-Root

Indian synonyms for square-root are *vargamūla* or *pada* of a *kṛti*. The word *mūla* means the "root" of a tree, which may also mean the "foot" or the lowest part or bottom of a thing and hence "pada" or foot also became a synonym of root. Brahmagupta defines square-root as follows :

The *pada* (root) of a *kṛti* (square) is that of which it is the square.¹

While the word *mūla* for root is the oldest in Indian literature (it occurs in *Anuyogadvāra-sūtra*, c. 100 B.C.), the word *pada* for root probably for the first time occurs in the writings of Brahmagupta. The term *mūla* was borrowed by the Arabs who translated it by *jadhr*, meaning "basis of square". The Latin term *radix* also is a translation of the term *mūla*. In the Śulba literature and in the Prākṛta texts, we find a term *karaṇi* for square-root. In geometry, this term *karaṇi* means a "side". In later days, the term *karaṇi* was reserved for surds, i.e. a square-root which cannot be exactly evaluated, but which may be represented by a line.

We would like to quote here a rule for determining square-root of numbers from the *Āryabhaṭṭya* :

Always divide the even place by twice the square-root (upon the preceding odd place); after having subtracted from the odd place the square (of the quotient), the quotient put down at the next place (in the line of the root) gives the root².

As an illustration, we shall proceed to find the square-root of 18225.

The odd and even places are marked out by vertical (I) and horizontal (—) lines : The other steps are as follows :

1. पदं कृत्स्नित् तत्

BrSpSi. XVIII. 35

2. मासं हरेदकारान्तित्वं दिगुणेन वर्गमूलेन ।
वर्गोदको शुद्धे लब्धं स्थानान्तरे सूत्रम् ॥

— Ārya, II. 4.

	1 - 1 - 1	
	1 8 2 2 5	
Subtract square	1	root = 1
Divide by twice		
the root	2) 8 (3	placing quotient at the
	6	next place, the root=13
	22	
Subtract square of		
quotient	9	
Divide by twice	26)132(5	placing quotient at the
the root	130	next place, the root=135
Subtract square	25	
of the quotient	25	

The process ends. The square-root of 18225 is thus 135.

It has been stated by Kaye, that Āryabhaṭa's method of finding out the square-root is algebraic in character, and that it resembles the method given by Theon of Alexandria. Āryabhaṭa's method is purely arithmetic and not algebraic is the view of Datta and Singh who do not agree with Kaye on this point.

Cube Root

The Sanskrit term for cube-root is *ghanamūla* or *ghanapada*. The first mention of the operation of cube-root is found in the *Āryabhaṭīya* of Āryabhaṭa I (499 A.D.), though the operation is given in only a concise form :

Divide the second *aghana* place by thrice the square of the cube-root; subtract from the first *aghana* place the square of the quotient multiplied by thrice the preceding (cube-root); and (subtract) the cube (of the quotient) from the *ghana* place; (the quotient put down) at the next place (in the line of the root) gives (the root).¹

As has been explained by all the commentators on the *Āryabhaṭīya*, the units place is *ghana*; the tens place is first *aghana*, the hundreds place is the second *aghana*, the thousands place is *ghana*, the ten thousands place is first *aghana*, the hun-

1. अघनाद् भजेद् द्वितीयात् त्रिगुणेन घनस्य मूलवर्गेण ।

वर्गस्त्रिपूर्वं गुणितशोधः प्रथमाद् घनस्य घनात् ॥

dred-thousands place is second *aghana*, and so on. Thus to find out the cube-root, one has to mark out the *ghana*, first *aghana* and second *aghana* places, then the process of finding out the cube-root begins with the subtraction of the greatest cube number from the figures up to the last *ghana* place. Though this has not been explicitly mentioned in the rule, the commentators say that it is implied in the expression *ghanasya mula-vargena* etc. ("by the square of the cube-root etc.")

We are reproducing here an illustration given by Datta and Singh.

Example. Find the cube-root of 1953125.

The places are divided into groups of three by marking them as below [*ghana* (|) first *aghana* (—) and second *aghana* (—)]:

	— — — —	
	1 9 5 3 1 2 5	
Subtract cube	<u>1</u>	(c) Root=1
Divide by thrice		
square of root,		
i.e. $3 \cdot 1^2$	3)9(2 ...	(a) Placing quotient
Subtract square	<u>6</u>	after the root 1
of quotient mul-	35	gives the root 12
tiplied by thrice	<u>12</u> ...	(b)
the previous root,		
i.e. $2^2 \cdot 3 \cdot 1$		
Subtract cube of	233	
quotient, i.e. 2^3	8 ...	(c)
Divide by thrice		
square of the root,		
i.e. $3 \cdot 12^2$	432)2251(5 ...	(a) Placing quotient
Subtract square of	<u>2160</u>	after the root
quotient multiplied		12 gives the
by thrice the pre-	912	root 125
vious root, i. e.		
$5^2 \cdot 3 \cdot 12$	<u>900</u>	
Subtract cube of	<u>125</u>	... (b)
quotient, i.e. 5^3	<u>125</u>	... (c)
Thus the cube-root=125.		

From the details given, it would be clear that the present

method of extracting the cube-root is almost a contraction of the method first given by Āryabhaṭa I (499 A.D.)

The method of Āryabhaṭa has been invariably followed by Indian mathematicians. Brahmagupta in his *Brahmasphuṭa-siddhānta* repeats the method in the following words :

The divisor for the second *aghana* place is thrice the square of the cube-root; the square of the quotient multiplied by three and the preceeding (root) must be subtracted from the next (*aghana* place to the right). and the cube (of the quotient) from the *ghana* place (the procedure repeated gives) the root.¹

Śrīdhara and Āryabhaṭa II have further improved on the method of extracting cube-root proposed by Āryabhaṭa I and followed by Brahmagupta. Rule for finding the cube-root as given by Śrīdhara in his *Pāṭiganita* is as follows :

(Divide the digits beginning with the units' place into periods of) one *ghana-pada* (one "cube" place) and two *aghana-pada*s (two "non-cube" places). Then subtracting the (greatest possible) cube from the (last) *ghana-pada* and placing the (cube) root underneath the third place (to the right of the last *ghana-pada*), divide out the remainder up to one place less (than that occupied by the cube root) by thrice the square of the cube-root, which, is not destroyed. Setting down the quotient (obtained from division) in the line (of the cube-root), (and designating the quotient as the 'first' (*ādima*) and the cube-root as the 'last' (*antya*), subtract the square of that quotient, as multiplied by thrice the 'last' (*antya*) from one place less than that occupied by the quotient (*uparima-rāśi*) as before, and the cube of the 'first' (*ādima*) from its own place.

(The number now standing in the line of cube-root is the cube-root of the given number up to its last-but one *ghana-pada* (cube place) from the left).

Again apply the rule, "(placing cube-root) under the third place" etc. (provided there be more than two *ghana-padas* (cube places) in the given number; and

1. द्वेदो घनाद् द्वितीयाद् घनमूलकृतिस्त्रिसंख्याप्लवृत्तिः ।

शोध्यो विपूर्वगुणिता प्रथमाद् घनतो घनो मूलम् ॥

—BrSpSi. XII. 7

continue the process till all *ghana-padas* (cube-places) are exhausted). This will give the (cube) root (of the given number).¹

K.S. Shukla in his translation and commentary of this book has given the illustration of extracting cube-root as follows :

Example :- To find the cube root of 277167808,

Let us indicate *ghana-padas* or 'cube' places by "c" and *aghana-padas* or non-cube places as "n" :

n n c n n c n n c
2 7 7 1 6 7 8 0 8

Subtract the greatest possible cube (i.e. 6^3 or 216) from the last 'cube' place (i.e. from 277) and place the cube-root (i.e. 6) underneath the third place to the right of the last 'cube' place; thus we have

n n c n n c n n c
6 1 1 6 7 8 0 8 (remainder)
6 (line of cube-root)

Dividing out by thrice the square of the cube-root (i.e. by $3 \cdot 6^2$ or 108) the remainder up to one place less than that occupied by the cube-root (i.e. 611) and setting down the quotient in the line of the cube-root (to the right of the cube-root), we have

n n c n n c n n c
7 1 6 7 8 0 8 (remainder)
6 5 (line of cube-root)

Let now quotient 5 be called the 'first' (*ādima*) and the cube-root 6 the 'last' (*antya*). Then subtracting the square of the 'first' (*ādima*) as multiplied by thrice the 'last' (*antya*) (i.e. $3 \times 6 \times 5^2$ or 450) from one place less than that occupied by the quotient (i.e. from 716), we get

1. घनपदमघनपदे द्वे घन (पद) तोऽपास्य घनमदौ मूलम् ।
संयोज्य तृतीयेपदस्याधस्तदनष्टवरेण ॥ २६ ॥
एकस्थानोनतया शेषं त्रिगुणेन (सं) भजेत्तस्मात् ।
लब्धं निवेश्य पञ्चम्यां तद्वर्गं त्रिगुणमन्यहत्तम् ॥ ३० ॥
जह्य यादुपरिमरारोः प्राप्तवद् घनमादिमस्य (च) स्वपदात् ।
भूयस्तृतीय पदस्याध शब्वादिक विधिर्भूतम् ॥ ३१ ॥

$$\begin{array}{r}
 n n c n n c n n c \\
 2667808 \quad \text{(remainder)} \\
 65 \quad \text{(line of cube-root)}
 \end{array}$$

And subtracting the cube of the 'first' (*adima*) (i.e. 5^3 or 125) from its own place (i.e. from 2667), we get

$$\begin{array}{r}
 n n c n n c n n c \\
 2542808 \quad \text{(remainder)} \\
 65 \quad \text{(line of cube-root)}
 \end{array}$$

One round of the operation is now over; and the number 65 standing in the line of the cube-root is the cube-root of the given number (277167808) up to its last-but-one 'cube' place (*ghana pada*) from the left (i.e. of 277167),

As there is one more 'cube' place (*ghana-pada*) on the right, the process is repeated. Thus placing the cube-root (i.e. 65) under the third place beginning with the last-but-one 'cube' place (*ghana-pada*), we have

$$\begin{array}{r}
 n n c n n c n n c \\
 2542808 \quad \text{(remainder)} \\
 65 \quad \text{(line of cube-root)}
 \end{array}$$

Dividing out 25428 by $3 \cdot 65^2 (=12675)$ as before, and placing the quotient in the line of the cube-root, we have

$$\begin{array}{r}
 n n c n n c n n c \\
 7808 \quad \text{(remainder)} \\
 652 \quad \text{(line of cube-root)}
 \end{array}$$

Subtracting $3 \times 65 \times 2^3 (=780)$ we get.

$$\begin{array}{r}
 n n c n n c n n c \\
 8 \quad \text{(remainder)} \\
 652 \quad \text{(line of cube-root)}
 \end{array}$$

Finally subtracting $2^3=8$ from 8, we get

$$\begin{array}{r}
 n n c n n c n n c \\
 0 \quad \text{(remainder)} \\
 652 \quad \text{(line of cube-root)}
 \end{array}$$

The second round of operation is now over. There being no more of *ghana-pada* ('cube' place) on the right, the process ends. The quantity in the line of cube root, viz., 652, is the cube-root of the given

number. The remainder being zero, the cube-root is exact.

Fractions

The concept of fractions in India can be traced to very early times. In the *Rgveda*,¹ we find such terms as one-half (*ardha*) and three-fourths (*tri-pāda*). In a passage of the *Maitrayaṇi Samhita*² are mentioned the fractions one-sixteenth (*kalā*), one-twelfth (*kuṣṭha*), one-eighth (*śapha*) and one-fourth (*pādā*). In the *Śulba Sūtras*³ we have not only a mention of fractions, but they have been used in the statement and solution of problems of geometric nature. Here in the *Śulba*, unit fractions are denoted by the use of cardinal number with the term *bhāga* or *aṁśa*; thus *pañca-daśa-bhāga* (literally "fifteen parts") is equivalent to one-fifteenth, *sapta-bhāga* (literally, "seven parts") is equivalent to one-seventh, and so on... The use of ordinal numbers with the term *bhāga* or *aṁśa* is also quite common: thus *pañcama bhāga* stands for one-fifth. The composite fractions like *tri-aṣṭama* stands for three-eighths and *dvi-saptama* for two-sevenths. In the *Bakhaṣālī Manuscript*, the term *tryaṣṭa* occurs for $3/8$ and $3\frac{3}{8}$ is called *trayastrayasta* (three-three-eighths).

The Sanskrit term for fraction is *bhinna* (literally meaning 'broken'). Obviously the European terms as *fractio*, *fraction*, *roupt*, *rotto* or *rocto* are translations of the same term; they are derived from the Latin *fractus* (*frangere*) or *ruptus* meaning 'broken'. The Indian term *bhinna* has a few more connotations; it stands for such numbers of the form :

$$\left(\frac{a}{b} \pm \frac{c}{d}\right), \left(\frac{a}{b} \text{ of } \frac{c}{d}\right), \left(\frac{a}{b} \pm \frac{c}{d} \text{ of } \frac{a}{b}\right) \text{ or } \left(a \pm \frac{b}{c}\right).$$

These forms were termed *jāti* i.e., 'classes', and the Indian treatises contain special rules for their reduction to proper fractions. Śrīdhara and Mahāvīra each enumerate six *jāti*s, while our author, Brahmagupta, gives only five (Bhāskara II gives only four). The need for division of fractions in 'classes' arose out of the lack of proper symbolism to indicate mathematical operations. (Datta and Singh *Arithmetic*, p. 188). The only operational symbol in use was a dot, standing for the negative sign.

1. *Rv.* X, 90,4

2. *Mait S.* III, 7,7.

3. B. Datta, *Śulba*, pp. 212ff.

Reduction to lowest terms.—A non-mathematical work, *Tattvārthādhigama-Sūtra-Bhāṣya* by Umāsvāti (c.150A.D.) casually mentions as follows in the context of a philosophic discourse:

Or, as when the expert mathematician, for the purpose of simplifying operations, removes common factors from the numerator and denominator of a fraction, there is no change in the value of the fraction, so...¹

Reduction to common denominator. Whenever we have to add or subtract fractions, we follow this reduction operation to a common denominator. Brahmagupta gives the reduction along with the similar processes :

By the multiplication of the numerator and denominator of each of the (fractional) quantities by other denominators, the quantities are reduced to a common denominator. In addition, the numerators are united, In subtraction their difference is taken.²

Fractions in combination :—Since there was no proper symbolism available to these early Indian mathematicians, they divided combination of fractions into four classes :

Bhāga, prabhāga, bhāgapavāha and bhāga-bhāga.

(i) *Bhāga* has been mentioned by Brahmagupta (BrSpSi.

XII. 8) thus : $\left(\frac{a}{b} \pm \frac{c}{d} \pm \frac{e}{f} \pm \dots \right)$ usually written as

$$\begin{array}{|c|c|c|} \hline a & c & e \\ \hline b & d & f \\ \hline \end{array} \text{ or } \begin{array}{|c|c|c|} \hline a & .c & .e \\ \hline b & d & f \\ \hline \end{array}$$

where the dots denote subtraction.

(ii) *Prabhāga* : The form $\left(\frac{a}{b} \text{ of } \frac{c}{d} \text{ of } \frac{e}{f} \dots \right)$

This is written as

$$\begin{array}{|c|c|c|} \hline a & c & e \\ \hline b & d & f \\ \hline \end{array}$$

(iii) *Bhāganubandha* : The form $\left(a + \frac{b}{c} \right)$ is written as

$$\begin{array}{|c|} \hline a \\ \hline b \\ \hline c \\ \hline \end{array}$$

1. II, 52.

2. विपरीतच्छेदगुणा : राशयोश्चेदंशकाः समच्छेदाः ।

संकलितेऽप्य योज्या व्यवकलितेऽप्यन्तरं कार्यम् ॥

—BrSpSi. XII. 2.

and the form

$$\frac{p}{q} + \frac{r}{s} \text{ of } \frac{p}{q} + \frac{t}{u} \text{ of } \left(\frac{p}{q} + \frac{r}{s} \text{ of } \frac{p}{q} \right) + \dots\dots\dots$$

is written as

$$\left[\begin{array}{c} p \\ q \\ r \\ s \\ t \\ u \end{array} \right]$$

(iv) *Bhāgāpavāha*, i.e., the form $\left(a - \frac{b}{c} \right)$ is written as

$$\left[\begin{array}{c} a \\ b \\ c \end{array} \right]$$

and the form $\frac{p}{q} - \frac{r}{s} \text{ of } \frac{p}{q} - \frac{t}{u} \text{ of } \left(\frac{p}{q} - \frac{r}{s} \text{ of } \frac{p}{q} \right) - \dots\dots\dots$

is written as

$$\left[\begin{array}{c} p \\ q \\ .r \\ s \\ .t \\ u \end{array} \right]$$

(v) *Bhāga-bhāga* : The form

$$\left(a \div \frac{b}{c} \right) \text{ or } \left(\frac{p}{q} \div \frac{r}{s} \right)$$

There does not appear to have been any notation for division, such compounds being written as

$$\left[\begin{array}{c} a \\ b \\ c \end{array} \right] \text{ or } \left[\begin{array}{c} p \\ q \\ r \\ s \end{array} \right]$$

just as for *bhāganubandha*. That division is to be performed was known from the problem, e.g., $1 \div \frac{1}{6}$ was written as *ṣaḍ-bhāga-bhāga*, i.e., "one-sixth *bhāga-bhāga*" or "one divided by one-sixth". It is only in the *Bakhṣālī Manuscript* that the term *bha* is sometimes placed before or after the quantity affected.

(vi) *Bhāga-mātr*, i.e., combinations of forms enumerated above. Mahāvira, the author of the *Gaṇitasārasaṃgraha* (850

A.D.) gives twenty-six variations of this class. We shall illustrate it by the following example from Śrīdhara :

What is the result when half, one-fourth of one-fourth, one divided by one-third, half-plus half of itself, and one-third diminished by half of itself, are added together ? (*Trisatika*, p. 12).

A modern writer would have written it as :

$$\frac{1}{2} + (\frac{1}{4} \text{ of } \frac{1}{4}) + (1 \div \frac{1}{3}) + (\frac{1}{2} + \frac{1}{2} \text{ of } \frac{1}{2}) (\frac{1}{3} - \frac{1}{2} \text{ of } \frac{1}{3})$$

In the old Indian notation, it is written as

1 — 2	1 — 4	1 — 4	1 — 3	1 — 2	1 — 3
				1	1
				2	2

The defect of the notation is obvious: $\left[\begin{array}{|c|c|} \hline 1 & 1 \\ \hline 4 & 4 \\ \hline \end{array} \right]$ can be read

also as $\frac{1}{4} + \frac{1}{4}$ and $\left[\begin{array}{|c|} \hline 1 \\ \hline 1 \\ \hline 3 \\ \hline \end{array} \right]$ can also be read as $1\frac{1}{3}$.

And therefore the original meaning is inferred from the context or from the enunciation of the problem.

The rules for reduction of the first two classes (*bhāga* and *prabhāga*) are those of addition or subtraction and multiplication. The rule for the reduction of the third (*bhāganubandha*) and fourth (*bhāgapavāha*) classes are given by Brahmagupta in the *Brāhmasphuṭa-siddhānta* thus :

The (upper) denominator is multiplied by the denominator and the upper numerator by the same (denominator) increased or diminished by its own numerator.¹

"Numerator" is known as "*amśa*" and the "denominator" as "*cheda*."

We give here from Śrīdhara's *Paṭiganīta* (about 900 A.D., according to K.S. Shukla, 750 A.D. according to Datta and Singh) a rule for reducing a fraction of the *bhāganubandha* class (i.e., a whole number increased by a fraction or a fraction increased by a fraction itself) :

1. ऊर्ध्वं शास्त्रेदुरुपास्तृतीयजातौ द्वयोः पृथक्परयोः ।

क्षेदैश्चेदा गुणितः स्वशायुतो नैरुपरिमाणाः ॥

—*BrSpSi. XII. 9.*

In the *bhāganubandha* class, the whole number (*rūpa-gaṇa*) is multiplied by the denominator (of the fraction) should be increased by the numerator (of the fraction) or the upper denominator having been multiplied by the lower denominator, the initial numerator (i.e. the upper numerator) should be multiplied by the sum of the lower numerator and denominator.¹

(*Paṭṅarīta*, 39 cf. *BrSpSi*. XII. 9 (ii); *GSS*. (iii) 113

This means that

$$(i) \quad a + \frac{b}{c} = \frac{ac+b}{c}$$

(ii) $\frac{a}{b} + \frac{c}{d}$ of $\frac{a}{b}$ (which was written by Indians in the style

$$\boxed{\begin{array}{c} \frac{a}{b} \\ \frac{c}{d} \end{array}}$$

is equal to $\frac{a(d+c)}{bd}$

Addition and Subtraction of Fractions

In the *Brahmasphuṭa-siddhānta*, Brahmagupta gives the rule for the addition and subtraction of fractions :

If the denominators (*cheda*) of fractions are different then reduce these fractions to a common denominator. Now for the additions, unite the numerators and take their difference in case of subtraction.²

Brahmagupta and Mahāvīra give the method under *Bhāga-jāti*.

Multiplication

Brahmagupta says :

The product of the numerators divided by the pro-

1. भागानुबन्धजतौ रूपगणशब्दे सङ्गुणः साराः ।

अवरहरज्जोर्ध्वं हरेऽधोराऽयुतहरज्ज आशंशः ॥

—*Paṭṅarīta* 39.

2. विपरीतच्छेदगुणाः राशयोश्चेदांशकाः समच्छेदाः ।

संकलितेऽशा योज्या व्यवकलितेऽशान्तरं कार्यम् ॥

—*BrSpSi*. XII. 2

duct of the denominators is the (result of) multiplication of two or more fractions.¹

While all other writers give the rule in the same way as Brahmagupta, Mahāvira in the *Gaṇitasārasaṃgraha* refers to cross reduction in order to shorten the work :

In the multiplication of fractions, the numerators are to be multiplied by the numerators and the denominators by denominators, after carrying out the process of cross reduction, if that be possible.²

Division of Fractions

The *Āryabhaṭīya* does not explicitly give the rule of division, but under the Rule of Three, we have an indication of this operation. The Rule of Three states the result as $\frac{f \times i}{p}$, where f stands for *phala* i.e. "fruit", i for *icchā*, i.e., demand or requisition, and p for *pramāṇa* i.e. argument. When these quantities are fractional, we get an expression of the form

$$\frac{\frac{a}{b} \times \frac{c}{d}}{\frac{m}{n}}$$

for the evaluation of which *Āryabhaṭa* I states :

The multipliers and the divisor are multiplied by the denominators of each other.

These quantities are written in the following way

a	m
b	n
c	
d	

Transferring the denominators we have

a	m
n	b
c	d

Performing multiplication, the result is $\frac{anc}{mbd}$. The above interpretation of the obscure line in the *Āryabhaṭīya* is based

1. रूपाणिच्छेद गुणान्यस्युक्तानि द्वयोर्वहूनां वा ।

प्रत्युत्पन्नो भवति च्छेदकवेनोदकृतोऽरावधः ॥

2. GSS. p. 25. (2)

on the commentaries of Sūryadeva and Bhāskara I (the commentary of Parameśvara on this line is vague and misleading). Sūryadeva in this connection says :

Here by the word *gunakāra* is meant the multiplier and multiplicand, i.e., the *phala* and *icchā* quantities that are multiplied together. By *Bhāgahara* is meant the *pramāṇa* quantity. The denominators of the *phala* and *icchā* are taken to the *pramāṇa*. The denominator of the *pramāṇa* is taken with the *phala* and *icchā*. Then multiplying these, i.e., (the numerators of) the *phala* and *icchā* and this denominator, and dividing by (the product of) the numbers standing with the *pramāṇa* the result is the quotient of the fractions.

Brahmagupta gives the method of division as follows :

The denominator and numerator of the divisor having been interchanged, the denominator of the dividend is multiplied by the (new) numerator. Thus division of proper fractions is performed.¹

Square and Square-Root of Fractions

Brahmagupta says as follows in this connection:—

The square of the numerator of a proper fraction divided by the square of the denominator gives the square.²

This rule of Brahmagupta has been followed by other authors also. The rule regarding the square-root as given by Brahmagupta is as follows :

The square-root of the numerator of a proper fraction divided by the square-root of the denominator gives the square-root.³

The Rule of Three :

The Indian term in Sanskrit for the Rule of Three is *Trairāśika* (literally, "three terms"). The term occurs in the *Bakhshali Manuscript* also, and also in the *Aryabhaṭṭya*, indicating the

1. : अरित्यं भागहारच्छेदांशौ द्वे संगुणच्छेदः ।
अंशोऽरागुणो भाज्यस्य भागहारः सर्वाणितयोः ॥ —BrSpSi. XII. 4
2. संवर्धितं शक्यं रवेद्वद्विमाजितो भवति वर्गः । —BrSpSi. XII. 5 (1)
3. संवर्धितान्मूलं वेदपदेनोद्घृतं मूलम् । —BrSpSi. XII. 5 (2)

antiquity of the term. Bhāskara in his commentary of the *Āryabhaṭīya* gives a justification of the use of this term for the Rule of Three thus :

Here three quantities are needed (in the statement and calculation) so the method is called *trairāśika* (meaning thereby the "rule of three terms").

The problem of the Rule of Three has the form :

If p (*pramāṇa*) yields f (*phala*), what will i (*icchā*) yield ?

Āryabhaṭa II (the author of the *Mahāsiddhānta*, 950 A.D.) uses the terms *māna*, *vinimaya* and *icchā*, instead of *pramāṇa*, *phala* and *icchā* respectively. It has also been pointed out by several authors that the first and third terms are similar, i.e., of the same denomination.

We shall give here the Rule of Three as given by Āryabhaṭa I and Brahmagupta :

In the Rule of Three, the *phala* ("fruit"), being multiplied by the *icchā* ("requisition") is divided by the *pramāṇa* ("argument"). The quotient is the fruit corresponding to the *icchā*. The denominators of one being multiplied with the other give the multiplier (i.e. numerator) and the divisor (i.e. denominator).¹

In the Rule of Three *pramāṇa* ("argument"), *phala* ("fruit") and *icchā* ("requisition") are the (given) terms; the first and the last terms must be similar. The *icchā* multiplied by the *phala* and divided by the *pramāṇa* gives the fruit (of the demand).²

Śrīdhara also gives the Rule of Three almost in the same words. Bhāskara II, Nārāyaṇa and others follow Brahmagupta and Śrīdhara in the *Trairāśika* operation. Śrīdhara in his *Pāṇiganita* says :

1. त्रैराशिकफलराशि तमथेच्छाराशिनाहतं कृत्वा ।
लब्धं प्रमाणभजितं तस्मादिच्छाफलमिदं स्यात् ॥
छेदाः परस्परं हता भवन्ति गुणकार भागहराणां ।
छेदगुणं सच्छेदं परस्परं तत्सर्वस्वत्वम् ॥

—Arya: II 26-27.

2. त्रैराशिके प्रमाणं फलमिच्छाद्यन्तयोः सदृशराशी ।
इच्छाफलेन गुणितं प्रमाणभक्ता फलं भवति ॥

—BrSpSi XII. 10

In (solving problems on) the Rule of Three, the argument (*pramāṇa*) and the requisition (*icchā*), which are of the same denomination, should be set down in the first and last places; the fruit (*phala*), which is of a different denomination, should be set down in the middle. (this having been done) that (middle quantity multiplied by the last quantity should be divided by the first quantity).¹

We shall illustrate the Rule of Three by an example from the *Pāṇiganita* (Example 25) :

Example, If 1 *pala* and 1 *karṣa* of sandalwood are obtained for ten and a half *panas*, then for how much will nine *palas* and one *karṣa* (of sandalwood) be obtained ?²

Here in this Example.

argument=1 *pala* and 1 *karṣa*= $1\frac{1}{4}$ or $\frac{5}{4}$ *palas*; fruit= $10\frac{1}{2}$ or $21\frac{1}{2}$ *panas*;

and requisition=9 *palas* and 1 *karṣa*= $9\frac{1}{4}$ or $\frac{37}{4}$ *palas*.

According to the Rule we shall write them as :

$$\begin{array}{|c|c|c|} \hline 1 & 10 & 9 \\ \hline 1 & 1 & 1 \\ \hline 4 & 2 & 4 \\ \hline \end{array}$$

Converting these into proper fractions we have

$$\begin{array}{|c|c|c|} \hline 5 & 21 & 37 \\ \hline 4 & 2 & 4 \\ \hline \end{array}$$

Then applying the rule, (i.e. multiplying the second and the last and dividing by the first), we have

$$\begin{array}{|c|c|} \hline 21 & 5 \\ \hline 2 & 4 \\ \hline 37 & \\ \hline 4 & \\ \hline \end{array}$$

$$\frac{21}{2} \times \frac{37}{4} = \frac{5}{4}$$

Or transferring denominators $\begin{array}{|c|c|} \hline 21 & 5 \\ \hline 4 & 2 \\ \hline 37 & 4 \\ \hline \end{array} = \frac{21.4.37}{5.2.4} \text{ pala}$

1. भाष्यन्तोस्त्रिराशवभिन्नजाती प्रमाणमिच्छा च ।

कर्ममन्त्रादिभ्यो तदन्त्यगुणमादिना विभजेत् ॥

2. चन्दनपत्रं सकर्षं सार्धैर्वदि लभ्यते पणैर्दशसि ।

तस्मिन् चन्दने पत्रानि नव कर्षयुक्तानि ॥

—*Pāṇiganita* 43.

—*Pāṇiganita*. Ex. 25.

=4 purāṇa, 13 paṇas, 2 kākinis and 16 varātakas. (One purāṇa is equivalent to 16 paṇas; one paṇa is equivalent to 4 kākinis, and One kākini is equivalent to 20 varātakas or cowries.

Inverse Rule of Three

This is known as *vyasta-trairāśika* (literally meaning "inverse rule of three terms"). After having described the rule of three, Brahmagupta proceeds to give an account of this inverse rule of three :

Divide the *phala* with *icchā* and multiply by *pramāṇa*; this gives the *vyasta-trairāśika* inverse rule of three¹.

Here *pramāṇa* is the argument also known as the first term and, and *phala* is the fruit also known as the middle term and *icchā* is known as requisition or the last term. As Bhāskara II clearly states, this rule is applied where with the increase of the *icchā*, the *phala* decreases or with its decrease the *phala* increases (*Līlavatī*).

Rule of Compound Proportion

Brahmagupta and other writers call the rule of compound proportions as *pañca-rāśika*, *sapta-rāśika* etc., meaning the rule of five terms, rule of seven terms etc. depending on the number of terms involved the problems. These are sometimes grouped under the general application of the "Rule of Odd Terms". Āryabhaṭa I (499 A.D.) though actually gives the rule of three appears to have been quite familiar with the rule of compound proportion also. In fact the difference between the rule of three and compound proportion is more or less artificial. This view was expressed by Bhāskara I (525 A.D.) in his commentary on the *Āryabhaṭīya* :

Here Ācārya Āryabhaṭa has described the Rule of Three only. How the well-known Rules of Five etc. are to be obtained ? I say thus : The Ācārya has described only the fundamentals of *anupāta* (proportion). All others such as the Rule of Five etc. follow from that fundamental rule of proportion. How ? The Rule of Five etc. consist of combinations of the Rule of Three.In the Rule of Five, there are two Rules of

1. व्यस्त त्रैराशिक फलमिच्छा भक्तः प्रमाणं फलमातः ।

त्रैराशिकादिषु फलं विधेयेकदशान्तेषु ॥

Three, in the Rule of Seven three Rules of Three, and so on. This I shall point out in the examples.

Brahmagupta gives the following rule relating to the solution of problems in compound proportion :

In the case of odd terms beginning with three terms up to eleven, the result is obtained by transposing the fruits of both sides, from one side to the other, and then dividing the product of the larger set of terms by the product of the smaller set. In all the fractions, the transposition of denominators, in like manner, takes place on both sides.¹

This may be illustrated by taking an example from the commentary of Pṛthudaka Svāmī on the *Brāhmasphuṭasiddhānta* :

Example — If there is an increase of 10 in 3 months on 100 (*niṣkas*), what would be the increase on 60 (*niṣkas*) in 5 months.

Here the *Pramāṇa pakṣa* (the first set of terms) is
100 *niṣkas*, 3 months, 10 *niṣkas* (*phala*)

The second set or the *icchā pakṣa* is
60 *niṣkas*, 5 months, *x niṣkas*

The terms are written in compartments as below :

100	60
3	5
10	0

In the above 10 (written lowest) is the *fruit* of the first side (*pramāṇa pakṣa*), and there is no *fruit* on the second side or the *icchā pakṣa*. Interchanging the *fruits* we get

100	60
3	5
0	10

The larger set of terms is on the second side (*icchā pakṣa*). The product of the numbers is 3,000. The product of the

1. व्यस्त त्रैशिक, फलमिच्छा भक्तः प्रमाणफलघातः ।

त्रैशिकादिषु फलं विपर्ययेकादशान्तेषु ॥

फलसंक्रमणमुपयतो बहुशशि वयोऽल्पवयस्यतो ज्ञेयम् ।

सकलेष्वेवं मिश्रैश्चैतस्येदं संक्रमणम् ॥

—BrSpSi. XII. 11-12.

number on the side of the smaller set of terms is 300. Therefore the required result is $\frac{3000}{300} = 10$.

Rule of Three as a Particular Case

According to Brahmagupta, the above method of "compound proportion" may be applied to the Rule of Three. Taking the example solved under the Rule of Three:

If one *pala* and one *karṣa* of sandal wood are obtained for ten and a half *panas*, for how much will be obtained nine *palas* and one *karṣa*?

(4 *karṣas* = 1 *pala*).

We shall represent them according to the Rule of Compound Proportion as

Pramāṇa pakṣa : 1 *pala*, 1 *karṣa*, 10½ *pana*
 or $\frac{5}{4}$ *pala*, $\frac{21}{2}$ *pana*
Icchā pakṣa : 9 *pala*, 1 *karṣa*, x *pana*
 or 37¼ *pala*, x *pana*

This we shall represent as

5	37
4	4
21	0
2	

Transposing the fruits, we have

5	37
4	4
0	21
2	

Transposing denominators

5	37
4	4
0	21
2	

The product of numbers on the side of the larger set is divided by the product of the numbers on the side of the smaller set, 0 in this case is not a number. It is the symbol for the unknown or absence. Hence the result is:

$$\frac{37.4.21}{5.4.2} \text{ panas}$$

The above method of working Rule of Three is found among Arabs, although it does not seem to have been used in India after Brahmagupta.

Problem Containing Quadratic Equation

Perhaps Āryabhaṭa I is the first man in the history of mathematics to give a solution of a quadratic equation (499 A.D.). In his *Āryabhaṭīya*, he gives a rule for the solution of the following problem (I am reproducing it as described by Datta and Singh):

The principal sum p ($=100$) is lent for one month (interest unknown $=x$). This unknown interest is then lent out for t ($=\text{six}$) months. After this period, the original interest (x) plus the interest on this interest amounts to A ($=16$). The rate-interest (x) on the principal (p) is required.

This problem requires the solution of the quadratic equation:—

$$tx^2 + px - Ap = 0$$

which gives $x = \frac{-p/2 \pm \sqrt{(p/2)^2 + Apt}}{t}$

The negative value of the radical does not give a solution of the problem; so that the result is

$$x = \frac{\sqrt{Apt + (p/2)^2} - p/2}{t}$$

This solution is stated by Āryabhaṭa I in the following words:

Multiply the sum of the interest on the principal and the interest (A) by the time (t) and by the principal (p). Add to this result the square of half the principal $(p/2)^2$. Take square-root this. Subtract half the principal ($p/2$) and divide the remainder by the time (t). The result will be the (unknown) interest (x) on the principal.¹

Here the Sanskrit terms are *mūla* for principal and *phala* for interest.

1. मूलफलं सफलं कालमूलगुणमर्धमूलकृत्तियुतं ।
मूलं मूलार्धेन कालद्वयं स्यात्सकमूलफलम् ॥

Brahmagupta (628 A.D.) gives a more general rule : He enunciates his problem thus :

The principal (p) is lent out for t_1 months and the unknown interest on this ($=x$) is lent out for t_2 months at the same rate and becomes A . To find x .

This evidently gives the quadratic :

$$x^2 + \frac{pt_1}{t_2} x - \frac{Apt_1}{t_2} = 0$$

whose solution is

$$x = \pm \sqrt{\frac{Apt_1}{t_2} + \left(\frac{pt_1}{2t_2}\right)^2} - \frac{pt_1}{2t_2}$$

The negative value of the radical does not give a solution of the problem, so it is discarded.

Brahmagupta states the formula thus :

Multiply the principal (p) by its time (t_1) and divide by the other time (t_2) (placing the result) at two places. Multiply the first of these by the mixture (A). Add to this the square of half the other. Take the square-root of this (sum). From the result subtract half the other. This will be the interest (x) on the principal.¹

A Problem on Interest

Brahmagupta gives a solution of a problem on interest :

In what time will a given sum s , the interest on which for t months is r , become k times itself ?

The rule for the solution of this problem as given by Brahmagupta is :

The given sum multiplied by its time and divided by the interest (*phala*), being multiplied by the factor (*guna*) less one, is the time (*required*).²

Miscellaneous Problems

Brahmagupta in his *Ganitādhyāya* of the *Brahmasphuṭa-siddhānta* gives numerous solutions in relation to miscellaneous problems. Here I shall be quoting a few of the problems which

1. कालप्रमाणघातः परकालद्वतो द्विधाऽऽवशिष्टवशात् ।

अन्यार्धकृतियुतात् पदमन्यार्धेन प्रमाणफलम् ॥

—BrSpSi. XII. 15.

2. कालगुणितं प्रमाणं फलभक्तं व्येकगुणद्वतं कालः ।

स्वफलयुतरूपभक्तं मूलफलैक्यं भवति मूलम् ॥

—BrSpSi. XII. 14.

have been quoted by his commentator Pṛthūdaka Svāmi in connection with one of his karaṇa-sūtra.¹

1. A horse was purchased by (nine) dealers in partnership, whose contributions were one, etc. up to nine; and was sold by them for five less than five hundred. Tell me what was each man's share of the sale proceed²

2. Four colleges (mathas), containing an equal number of pupils, were invited to partake of a sacrificial feast. A fifth, a half, a third and a quarter (of the total number of pupils in the college) came from the respective colleges to the feast; and added to one, two, three and four, they were found to amount to eighty-seven; or, with those deducted, they were sixty seven. Find the actual number of the pupils that came from each college.³

3. Three (unequal) jars of liquid butter, of water and of honey, contained thirty-two, sixty and twenty-four *Pala* respectively; the whole was mixed together and the jars filled again. Tell me the quantity of butter, of water and of honey in each jar⁴.

1. प्रक्षेपयोगहृत्या लब्ध्वा प्रक्षेपका गुण्या लाभः ।

ऊनाधिकोत्तरास्तथुतो नया स्वफलमूनयुत ॥

BrSpSi. XII. 16.

2. एकाद्यैर्नव पर्यन्तैर्विणिजैर्मूलराशिभिः ।

क्रीतो ह्योऽसौ विक्रीतः पञ्चोनैः पञ्चोनैः पंचभिः शतैः ।

किमैकैकस्य तत्रासीद् ब्रूहि त्वं मिश्रकान् सम ॥

3. मठस्थानानि चत्वारि छात्राणां समसंख्यया ।

भोक्तुं संमन्त्रितान्यासन् दीक्षायां किल यज्वना ॥

पंचावध्विचतुर्थीशास्तेभ्यो भोक्तुं समागताः ।

एकदिनिचतुर्थ्युक्ता दद्याशीतिः सप्ततका ॥

एवोत्तरैरथवा हीना सप्तषष्टिश्चतैः ऽशकाः ।

मठेभ्यश्छात्रसंख्यां ज्ञेयं ब्रूहि ये क्षमता यतः

4. धृतोदकमधूनां ये ज्ञेयः कलसकाः पलैः ।

रदषष्टिभिः पूर्या एकीभूतास्ततः पुनः ॥

मिश्रेण पूरिता यावत् तावत् संख्यां न वेद्म्यहम् ।

धृतोदकमधूनां तामैकैकत्रं गतां वद ॥

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CHAPTER IX

Brahmagupta as an Algebraist

Ancient Indian name for algebra is *Bijaganita* where *bija* means *element* or *analysis* and *ganita* stands for the *science of calculation*. As early as 860 A.D., Pṛthūdaka Svāmi used this epithet for algebra in his commentary. Brahmagupta calls algebra as *Kuṭṭakaganita* or merely *kuṭṭaka*, a term which was later on used for "*pulveriser*" which deals with that special section of algebra which is connected with indeterminate equations of the first degree. Algebra is often also known as *avyakta-ganita* or the calculations with *unknowns*, in contrast to arithmetic which was known as *vyakta-ganita* or the calculations with *knowns*.

Algebra goes to Europe from India

In the history of mathematical sciences, as Colebrooke rightly remarks, it has long been a question to whom the invention of algebraic analysis is due. There is no doubt that Europe got algebra from Arabs mediately or immediately. But the Arabs themselves scarcely pretend to the discovery of algebra. Colebrooke says that they were not in general inventors but scholars during the short period of their successful culture of the sciences; and the germ at least of the algebraic analysis is to be found among the Greeks in an age not precisely determined, but more than probably anterior to the earliest dawn of civilisation among the Arabs; and this science in a more advanced state subsisted among the Hindus prior to the earliest disclosure of it by the Arabians to modern Europe. (Colebrooke: *Dissertation on the Algebra of the Hindus*)¹.

Colebrooke based his observations on the texts he could procure for his studies. These were : Bhāskara II's *Bijaganita* or *Vijaganita* (1150 A.D.) and *Līlāvati* (1150 A.D.), the *Gaṇitādhyāya* and *Kuṭṭakādhyāya* of Brahmagupta in his famous treatise the *Brahma Siddhānta* or rather the *Brahmasphuṭasiddhānta* (628

1. Colebrooke, H. T., *Miscellaneous Essays*, Vol. II, 1872, p. 418.

A.D.). There can be no doubt regarding the age of these two authors. Bhāskara II completed his great work on the *Siddhanta-siromani* in 1072 Śaka, and *Karaṇa-kutūhala* a practical astronomical treatise in 1105 Śaka; these dates are based on the passages given by Bhāskara himself in his works. The *Bija-ganita* and the *Lilāvati* form parts of the great treatise, the *Siddhanta-siromani*. The genuineness of the text is established, as Colebrooke says, with no less certainty by numerous commentators in Sanskrit, besides a Persian version of it. Those commentaries comprise a perpetual gloss, in which every passage of the original is noticed and interpreted : and every word of it is repeated and explained. From comparison and collation of various texts, it appears then that the work of Bhāskara, exhibiting the same uniform text which the modern transcripts of it do, was in the hands of both Muhammedans and Hindus, between two or three centuries ago : and numerous copies of it having been diffused throughout India, at an earlier period, as of a performance held in high estimation, It was the subject of study and habitual reference in countries and places so remote from each other as the north and west of India and the Southern Peninsula.

This though not marking any extraordinary antiquity, nor approaching to that of the author himself, was a material point to be determined : as there will be in the sequel, so says Colebrooke, occasion to show, that modes of analysis, and in particular, general methods for the solution of indeterminate problems both of the first and second degrees, are taught in the *Bija-ganita*, and those for the first degrees repeated in the *Lilāvati*, which were unknown to the mathematicians of the West, until invented anew in the last two centuries by algebraists of France and England.¹ Bhāskara who himself flourished more than six hundred and fifty years ago, was in this respect a compiler and took those methods from Indian authors as much more ancient than himself.

Regarding the age of the precursors of Bhāskara II, Colebrooke says : The age of his precursors cannot be determined with equal precision. He then proceeds to examine the evidence as follows :

¹ Colebrooke, H. T., *Miscellaneous Essays*, p. 421.

Towards the close of his treatise on Algebra, Bhāskara II informs us, that it is compiled and abridged from the more diffuse works on the same subject, bearing the names *Brāhme* (meaning no doubt Brahmagupta), Śrīdhara and Padmanābha; and in the body of his treatise, he has cited a passage of Śrīdhara's algebra and another of Padmanābha. He repeatedly adverts to preceding writers and refers to them in general terms, where his commentators understand him to allude to Āryabhaṭa, to Brahmagupta to the latter's scholiast Caturveda *Prthūdaka Svāmī* and to the other writers above mentioned.

Most, if not all, of the treatises, to which he thus alludes, must have been extant, and in the hands of his commentators, when they wrote; as appears from their quotations of them; more especially those of Brahmagupta and Āryabhaṭa, who are cited, and particularly the first mentioned, in several instances. A long and diligent research in various parts of India, has, however, failed of recovering any part of the *Padmanābha Bija* (or the algebra of Padmanābha) and of the algebraic and other works of Āryabhaṭa.

But the translator has been more fortunate in regard to the works of Śrīdhara and Brahmagupta, having in his collection Śrīdhara's compendium of arithmetic, and a copy incomplete however, of the text and scholia of Brahmagupta's *Brahmasiddhānta* comprising among other no less interesting matter, a chapter treating of arithmetic and mensuration; and another, the subject of which is algebra: both of them fortunately complete. The commentary is a perpetual one; successively quoting in length each verse of the text; proceeding to the interpretation of it, word by word; and subjoining elucidations and remarks; and its colophon, at the close of each chapter, gives the title of the work and the name of the author. Now the name which is there given, Caturveda *Prthūdaka Svāmī*, is that of a celebrated scholiast of Brahmagupta, frequently cited as such by the commentaries of

Bhāskara and by other astronomical writers; and the title of the work, *Brahmasiddhānta* or sometimes *Brahmasphuṭasiddhānta*, corresponds, in the shorter form, to the known title of Brahmagupta's treatise in the usual references to it by Bhāskara's commentators, and answers, in the longer form, to the designation of it, as indicated in an introductory couplet which is quoted from Brahmagupta by Lakṣmidāsa, a scholiast of Bhāskara II. Remarking this coincidence, the translator proceeded to collate, with the text and commentary, numerous quotations from both, which he found in Bhāskara's writings or in those of his expositors. The result confirmed the indication and established the identity of both text and scholia as Brahmagupta's treatise, and the gloss of Pṛthūdaka. The authenticity of the *Brahmasiddhānta* is further confirmed by numerous quotations in the commentary of Bhaṭṭotpala on the *Samhitā* of Varāhamihira : as the quotations from the *Brahmasiddhānta*, in that commentary, (which is the work of an author who flourished eight hundred and fifty years ago) are verified in the copy under consideration. A few instances of both will suffice, and cannot fail to produce conviction.

It is confidently concluded, that the chapters on arithmetic and algebra, fortunately entire in a copy in many parts imperfect, of Brahmagupta's celebrated work as here described, are genuine and authentic. It remains to investigate the age of the author.

Mr. Davis, who first opined to the public a correct view of the astronomical computations of the Hindus, is of opinion, that Brahmagupta lived in the seventh century of the Christian era. Dr. William Hunter, who resided for some time with a British Embassy at Ujjayinī, and made diligent researches into the remains of Indian science at that ancient seat of Hindu astronomical knowledge, was there furnished, by the learned astronomers whom he consulted, with the ages of the principal ancient authorities. They assigned to Brahmagupta the date of 550 Saka; which answers to A.D.

628. The grounds on which they proceeded are unfortunately not specified: but as they gave Bhāskara's age correctly, as well as several other dates right, which admit of being verified; it is presumed that they had grounds, though unexplained, for the information which they communicated.

Mr. Bentley, who is little disposed to favour the antiquity of an Indian astronomer, has given his reasons for considering the astronomical system which Brahmagupta teaches, to be between twelve and thirteen hundred years old (1263 years in A.D. 1799). Now as the system taught by this author is professedly one corrected and adapted by him to conform with the observed positions of the celestial objects when he wrote, the age, when their positions would be conformable with the results of computations made as by him directed, is precisely the age of the author himself: and so far as Mr. Bentley's calculations may be considered to approximate the truth, the date of Brahmagupta's performance is determined with like approach to exactness, within a certain latitude however of uncertainty for allowance to be made on account of the inaccuracy of Hindu observations.

The translator has assigned on former occasions the grounds upon which he sees reason to place the author's age, soon after the period when the vernal equinox coincided with the beginning of the lunar mansion and zodiacal asterism *Āśvini*, where the Hindu ecliptic now commences. He is supported in it by the sentiments of Bhāskara and other Indian astronomers, who infer from Brahmagupta's doctrine concerning the solstitial points, of which he does not admit a periodical motion, that he lived when the equinoxes did not, sensibly to him, deviate from the beginning of *Āśvini* and middle of *citra* on the Hindu sphere. On these grounds it is maintained, that Brahmagupta is rightly placed in the sixth or beginning of the seventh century of the Christian era, as the subjoined calculations will more particularly show. The age when Brahmagupta

flourished, seems then, from the concurrence of all these arguments, to be satisfactorily settled as antecedent to the earliest dawn of the culture of sciences among the Arabs; and *consequently establishes* the fact, that *the Hindus were in possession of algebra before* it was known to the Arabians.

Brahmagupta's treatise, however, is not the earliest work known to have been written on the same subject by an Indian author. The most eminent scholiast of Bhāskara II (Gaṇeśa) quotes a passage of Āryabhaṭa specifying algebra under the designation of *Bija*, and making separate mention of *Kuṭṭaka*, which more particularly intends a problem subservient to the general method of resolution of indeterminate problems of the first degree: he is understood by another of Bhāskara's commentators to be at the head of the elder writers, to whom the text then under consideration adverts, as having designated by the name of *Madhyamāharaṇa* the resolution of affected quadratic equations by means of the completion of the square. It is to be presumed, therefore, that the treatise of Āryabhaṭa then extant, did extend to quadratic equations in the determinate analysis, and to indeterminate problems of the first degree; if not to those of the second likewise, as most probably it did.

This ancient astronomer and algebraist, so says Colebrooke, was anterior to both Varāhamihira and Brahmagupta, being repeatedly named by the latter; and the determination of the age when he flourished is particularly interesting as his astronomical system, though on some points agreeing, essentially disagreed on others, with that which the Hindu astronomers still maintain.

He, as Colebrooke says, is considered by the commentators of the *Śūryasiddhānta* and *Śiromaṇi*, as the earliest of uninspired and mere human writers on the science of astronomy, as having introduced requisite corrections into the system of Parāśara, from whom he took the numbers for the planetary mean motions; as

having been followed in the tract of emendation, after a sufficient interval to make further correction requisite, by Durgāsinha and Mihira; who were again succeeded after a further interval by Brahmagupta, son of Jīṇu.

In short, says Colebrooke, Āryabhaṭa was founder of one of the sets of Indian astronomers, as Puliśa, an author likewise anterior to both Varāhamihira and Brahmagupta, was of another : which were distinguished by names derived from the discriminative tenets respecting the commencement of planetary motions at sunrise according to the first, but at midnight according to the latter, on the meridian of Lankā, at the beginning of the great astronomical cycle. A third sect began the astronomical day, as well as the great period, at noon.

Āryabhaṭa's name accompanied the intimation which the Arab astronomers (under the Abbasside Khalifs, as it would appear,) received, that three distinct astronomical systems were current among the Hindus of those days : and it is but slightly corrupted, certainly not at all disguised, in the Arabic representation of it *Arjabahar*, or rather *Arjabhar*, (corrupted form of Āryabhaṭa). The two other systems were, first, Brahmagupta's *Siddhānta* which was the one they became best acquainted with, and to which they apply the denomination of the *sind-hind*; and second, that of *Arca*, the Sun, which they write *Arcand* a corruption still prevalent in the vulgar Hindi.

Āryabhaṭa appears to have had more correct notions of the true explanation of celestial phenomena than Brahmagupta himself, so says Colebrooke; who in a few instances, correcting errors of his predecessor, but oftener deviating from that predecessor's juster views, has been followed by the herd of modern Hindu astronomers, in a system not improved, but deteriorated, since the time of the more ancient author.

Considering the proficiency of Āryabhaṭa in astronomical science, and adverting to the fact of his having

written algebra, as well as to the circumstance of his being named by numerous writers as the founder of a sect, or author of a system in astronomy, and being quoted at the head of algebraists, when the commentators of extant treatises have occasion to mention early and original writers on this branch of science, it is not necessary to seek further for a mathematician qualified to have been the great improver of the analytic art, and likely to have been the person by whom it was carried to the pitch to which it is found to have attained among the Hindus, and at which it is observed to be nearly stationary through the long lapse of ages which have since passed : the later additions being few and unessential in the writings of Brahmagupta, of Bhāskara and of Jñānarāja, though they lived at intervals of centuries from each other.

Āryabhaṭa, Colebrooke rightly says, then being the earliest author known to have treated of Algebra among the Hindus, and being likely to be, if not the inventor, the improver of that analysis, by whom too it was pushed nearly to the whole degree of excellence which it is found to have attained among them; it becomes in an especial manner interesting to investigate any discoverable trace in the absence of better and more direct evidence, which may tend to fix the date of his labours; or to indicate the time which elapsed between him and Brahmagupta, whose age is more accurately determined.

Taking Āryabhaṭa, for reasons given, to have preceded Brahmagupta and Varāhamihira by several centuries; and Brahmagupta to have flourished more than twelve hundred years ago, and Varāhamihira, concerning whose works and age, Colebrooke has given a few notes, and has placed him at the beginning of the sixth century after Christ, it appears probable that this earliest of known Hindu algebraists wrote as far back as the fifth century of the Christian era; and perhaps in an earlier age. Hence it is concluded that he is nearly as ancient as the Grecian algebraist Diophantus, sup-

posed on the authority of Abulfaraj, to have flourished in the time of the Emperor Julian or about A. D. 360.

Colebrooke further says: Admitting the Hindu and Alexandrian authors to be nearly equally ancient, it must be conceded in favour of the Indian algebraist, that he was more advanced in the science; since he appears to have been in possession of the resolution of equations involving several unknowns, which it is not clear, nor fairly presumable, that Diophantus, knew; and a general method of indeterminate problems of at least the first degree, to a knowledge of which the Grecian algebraist had certainly not attained; though he displays infinite sagacity and ingenuity in particular solutions; and though a certain routine is indiscernible in them.

Colebrooke appears to be of the view that Greeks were the first to discover the solution of equations involving one unknown; and this knowledge was passed to ancient Indians by their Greek instructors in improved astronomy. But "by the ingenuity of the Hindu-scholars, the hint was rendered fruitful and the algebraic method was soon ripened from that slender beginning to the advanced state of a well arranged science, as it was taught by Āryabhata, and as it is found in treatises compiled by Brahmagupta and Bhāskara."

We do not agree with this analysis in entirety. Indian algebra is entirely of Indian roots. It had its beginning in the times of Samhitās and Brāhmaṇas. Some of the equations and problems were solved by geometric methods. It must have had its origin in the Śulba period if not before. Āryabhata undoubtedly was the discoverer of many algebraic solutions of equations of the first and higher order with one and more unknowns. It is rather too much to trace the influence of Diophantus on Indian algebra which developed in this country independently. Brahmagupta is one of the most brilliant algebraists we ever had in the entire history of mathematics.

Technical Terms

Coefficient—

In the ancient Indian algebra, there is no systematic term for the coefficient. Usually, the power of the unknown is mentioned when the reference is to the coefficient of that power. At one place, for example, we find Pṛthūdaka Svāmī (the commentator of Brahmagupta's *Brahmasphuṭasiddhānta*) writing "the number (*aṅka*) which is the coefficient of the square of the unknown is called the 'square' and the number which forms the coefficient of the (simple) unknown is called the 'unknown quantity' (*avyakta-māna*)."¹ However, at many places, we find the use of a technical term also. Brahmagupta once calls the coefficient *saṁkhyā*² (number) and on several other occasions *gunaka*³ or *gunakāra*⁴ (multiplier). Pṛthūdaka Svāmī (860 A.D.) calls it *aṅka* (number) or *prakṛti* (multiplier). These terms may also be seen in the works of Śrīpati⁵ (1039) and Bhāskara II⁷ (1150 A.D.). The former also used the word *rūpa* for the same purpose.⁸

Unknown Quantity

The unknown quantity has been termed as *yāvat-tāvat* (meaning so-much-as or as-many-as) in literature as early as 300 B. C. (vide the *Sihānāṅga-sūtra*⁹). In the *Bakhasālī Manuscript*, it has been termed as *yadycchā*, *vāñchā* or *kāmikā* (or any desired quantity)¹⁰. Āryabhaṭa I in one of his verses calls the unknown as *gulika*¹¹ (literally meaning a shot) From the early seventh century A.D., the word *avyakta* was used for unknown quantities. Brahmagupta uses this term in his *Brahmasphuṭasiddhānta*¹²

1. BrSpSi. XVIII. 44 (Com.)

2. वर्षप्रमाण भावितघातो भवतीष्ट वर्ष संख्यैवम् ।

—BrSpSi. XVIII 63

3. मूलं द्विषेष्ट वर्गाद् गुणक गुणादिष्ट युत विहीनाच्च ।

—BrSpSi. XVIII 64

वर्गच्छिन्ने गुणके प्रथमं तन्मूल भाजितं भवति ।

—BrSpSi. XVIII 70

4. प्रथमोन्यमूलमन्यो गुणकार पदोद्धृतः प्रथमः ।

—BrSpSi. XVIII 69

5. BrSpSi XVIII. 44 (Com.)

6. Siśe XIV. 33-5.

7. *Bījaganita*

8. Siśe XIV. 33-5.

9. *Sūtra* 747.

10. BMs. Folio 22, verso; 23, recto and verso.

11. गुलिकान्तरेण विभजेद् द्वयोः ।

12. अन्यक्तव्यं धनवर्गं वर्गपञ्चमं षड्गतादीनाम् ।

Power

Since long, the word *varga* has been used for the second power; the word also stands for *square* (*Uttarādhyaṇa Sūtra*¹, B. C. c. 300). The third power is similarly known as *ghana*, the fourth power as *varga-varga* (square-square), the sixth power as *ghana-varga* (cube-square) and the twelfth power as *ghana-varga-varga* (cube-square-square). In later days, the fifth power was called *vargaghana ghāta* (here the word *ghāta* means product; the term means product of cube and square). The former system was multiplicative, rather than additive; whereas the latter was on the additive system. The seventh power on the additive system was known as *varga-varga-ghana-ghāta* (product of square-square and cube). Brahmagupta, however, uses a more scientific system for expressing the powers more than four. He calls the fifth power as *Pañca gata* (literally meaning, raised to the fifth), the sixth power as *ṣaḍ-gat* (raised to the sixth) and so on, thus adding the suffix *gata* to the name of the number indicating that power.² Bhāskara II has followed the system of Brahmagupta almost consistently for powers one and upwards.

Equation

Perhaps Brahmagupta has for the first time used the term *samakarāṇa* or *samīkarāṇa* (literally meaning making equal) or simply *sama* (equal or equation)³. Pṛthūdaka Svāmī (860) employs the term *sāmya* (equality or equation) for equation⁴. The equation is said to possess two *Pakṣas*⁵ (sides) *Itara-Pakṣa* and *apara-pakṣa*.

Absolute Term

Brahmagupta uses the term *rūpa* (literally meaning appearance) for an absolute term. It represents the visible or known

1. Chapter XXX, 10, 11.

2. अव्यक्तवर्गं घनवर्गं-वर्गं-चतुर्गुणं-वर्गवर्गं-संख्यैवम् ।
सदृशं द्विवधो वर्गसंख्यादि वधस्तद्वर्गतोऽन्यं जातिवधः ॥
3. वर्गं प्रमाणं भावित-वातो भवतीष्टवर्गं संख्यैवम् ।
सिध्यति विनाऽपि भावित-प्रसङ्गस्यात् किं कृतं तदतः ॥
अव्यक्तान्तरं भक्तं व्यक्तं रूपान्तरं समेऽव्यक्तः ।

4. *Sīse*, XIV, 19.

5. *Bījagaṇita*.

portion of the equation whilst its other part is practically invisible or unknown¹.

Unknowns and Symbolism

Āryabhaṭa I (499 A. D.) probably used coloured *gulikas* or shots for representing different unknowns. Brahmagupta mentions *varṇa* as the symbols for unknown. He has, however, not indicated how these *varṇas* or colours were used as symbols for unknowns. Perhaps we might conclude from this that the method of using colours as symbols for unknown quantities was very common and familiar to the algebraists. Datta and Singh say that the Sanskrit word *varṇa* denotes colour as well as a letter of alphabet, and therefore, letters of alphabet came into use for unknown quantities: *kālaka* (black), *nilaka* (blue), *pīṭaka* (yellow), *lohita* (red), *haritaka* (green), *śvetaka* (white), *citraka* (variegated), *kapilaka* (tawny), *pingalaka* (reddish-brown), *dhūmraka* (smoke-coloured), *pāṭalaka* (pink), *śaralaka* (spotted), *syāmalaka* (blackish), *mecaka* (dark blue) etc².

It should be further noted that the first unknown quantity *yāvat-tāvat* is not a *varṇa* or colour. It thus clearly indicates that the use of colours as symbols came at a later stage, whilst the word *yāvat-tāvat* was in currency from much earlier times. Some authorities think that the term *yāvat-tāvat* is a corrupted form of *yāvakaśtāvat* (where *yāvaka* means red). Pṛthūdaka Svāmi has sometimes used the term *yāvaka* for an unknown quantity³.

Laws of Signs

Brahmagupta has in his Chapter XVIII devoted a special section entitled "*Dhanarṇa Śūnyānam Samkalanam*" or calculations dealing with quantities bearing positive and negative signs and zero,

1. अव्यक्तान्तरं भवति व्यस्तं रूपान्तरं समेऽव्यक्तः । —BrSpSi XVIII. 43
वर्गं चतुर्गुणितानां रूपाणां मध्यमं सहितानाम् ॥ —BrSpSi XVIII. 44
2. यावत्-तावत् कालको नीलकोऽन्यो वर्णः पीतो लोहितश्चैतदाद्याः ।
अव्यक्तानां कल्पिता मानसंज्ञास्तत्संख्यानं कर्तुं मानार्थवर्धनं ॥
यावत्-तावत् कालक नीलक पीताश्च लोहितो हरितः ।
श्वेतक चित्रक कपिलक पाटलकाः पण्डु धूम्र शकलाश्च ॥
श्यामलक-मेचक-धवलक-पिशङ्ग-शारङ्ग-वज्र-गौराद्याः । —Nārāyaṇa, *Bījagaṇita*
3. BrSpSi XII. 15, (Com.) ; XII 18.

Regarding *addition*, Brahmagupta says :

The sum of two positive numbers is positive, of two negative numbers is negative; of a positive and negative number is the difference¹.

Regarding *subtraction*, Brahmagupta further says :

From the greater should be subtracted the smaller; (the final result is) positive, if positive from positive, and negative, if negative, from negative. If, however, the greater is subtracted from the less, that difference is reversed (in sign), negative becomes positive and positive becomes negative. When positive is to be subtracted from negative or negative from positive, then they must be added together².

Mahāvira (850 A. D.), Bhāskara II (1150 A.D.) and Nārāyaṇa (1350 A. D.) have also given similar rules regarding addition (*Saṁkalanam*) and the subtraction (*vyavakalanam*).

Again, the rule given by Brahmagupta regarding *Multiplication* is as follows :

The product of a positive and a negative (number) is negative; of two negatives is positive; positive multiplied by positive is positive³.

His rule regarding *division* is as follows :

Positive divided by positive or negative divided by negative becomes positive. But positive divided by negative and negative divided by positive remains negative⁴.

Similar rules for multiplication and division were provided by later authorities as Mahāvira and Bhāskara II.

1. *BrSpSi XII. 15. (Com.); XII 18. (Com.)*
2. धनयोर्वैनमृणमृणयोर्वैनर्णं योरन्तरं समैवयं खम् ।
ऋणमैवयं च धनमृणधन शून्ययोः शून्ययोः शून्यम् ॥ —*BrSpSi. XVIII-30*
3. कनमधिकादिशोध्यं धनं धनादृणमृणादधिकमूनात् ।
व्यस्तं तदन्तरं स्यादृणं धनं धनमृणं भवति ॥
शून्यविहीनमृणमृणं धनं धनं भवति शून्यमाकाशम् ।
शोध्यं यदा धनमृणादृणं धनाद्वा तदा क्षेप्यम् ॥ —*BrSpSi XVIII. 31-32*
4. ऋणमृणधनयोर्धातो धनमृणयोर्वैनवधो धनं भवति ।
शून्यैर्णयोः ख धनयोः ख शून्ययोर्वा वधः शून्यम् ॥ —*BrSpSi XVIII. 33*
5. धनभक्तं धनमृणहृतमृणं धनं भवति खं खभक्तं खम् ।
भक्तमृणेन धनमृणं धनेन हृतमृणमृणं भवति ॥ —*BrSpSi. XVIII. 34*

Brahmagupta lays down the rules regarding *evolution* and *involution* as follows :

The square of a positive or a negative number is positive
.....The (sign of the) root is the same, as was that from
which the square was derived¹.

As regards the latter portion of this rule, Pṛthūdaka Svāmī has the following comment to make : "The square-root should be taken either negative or positive, as will be most suitable for subsequent operations to be carried on."

It will be interesting to observe the following observation of Mahāvīra (850 A. D.) regarding square-root of a negative quantity "Since a negative number by its own nature is not a square, it has no square-root."² So says Śrīpati : "A negative number by itself is non-square, so its square-root is unreal; so the rule (for the square-root) should be applied in the case of a positive number."³

Algebraic Operations

Brahmagupta and other algebraists recognise six operations as fundamental in algebra : addition, subtraction, multiplication, division, squaring and the extraction of the square-root.

Regarding *addition* and *subtraction* Brahmagupta says :

Of the unknowns, their squares, cubes, fourth powers, fifth powers, sixth powers, etc., addition and subtraction are (performed) of the like; of the unlike (they mean simply their) statement severally.⁴

In place of "of the like", Bhāskara II uses the term "of those of the same species (*jāti*) amongst unknowns" :

Addition and subtraction are performed of those of the same species (*jāti*) amongst unknowns; of different species they mean their separate statement.⁵

1. खोदधृत मृणं धनं वा तच्छेदं खमृणधनविभक्तं वा ।

ऋणधनयोर्वर्गः स्वं स्वं स्वस्य पदं कृतिर्यत् तत् ॥

—BrSpSi, XVIII. 35

2. GSS, I, 52.

3. Śiśe, XIV, 5.

4. अव्यक्तवर्गं धनकर्म वर्गं पंचगतं षड्गतादीनाम् ।

तुल्यानां संकलितं व्यवकलिते पृथगतुल्यानाम् ॥

—BrSpSi, XVIII. 41.

5. योगोऽन्तरं तेषु समानं जाल्योर्विभिन्नं जाल्योश्च पृथक् स्थितिश्च ।

—Bhāskara II, Bijaganita.

This means that the numerical coefficients of x cannot be added to or subtracted from the numerical coefficients of y or x^2 or x^3 or xy and so on because these terms belong to different *jāti* or they do not belong to the category of the "like".

Again, regarding *multiplication*, Brahmagupta says :

The product of the two like unknowns is a square; the product of three or more like unknowns is a power of that designation. The multiplication of unknowns of unlike species is the same as the mutual product of symbols; it is called *bhāvita* (product or factum).¹

Having given the rules of the operations for addition, subtraction and multiplication, Brahmagupta does not think it necessary to deal with other operations. His section on the calculations with zero, negative and positive quantities ends here.

How is an Equation Formed?

Prthūdaka Svāmī while commenting on a verse in *Brāhma-sphuṭasiddhānta* speaks as follows :

In this case, in the problem proposed by the questioner, *yāvat-tāvat* is put for the value of the unknown quantity. Then performing multiplication, division etc. as required in the problem the two sides shall be carefully made equal. The equation being formed in this way, then the rule (for its solution) follows.²

Plan for Writing Equations

When in regards to a given problem, an equation has been formed, it has to be written down for further operations. This writing down of an equation is technically known as *nyāsa*. Perhaps the oldest record of *nyāsa* is to be found in the *Bakhaṣālī Manuscript*. According to the procedure prescribed in this work, the two sides of an equation are put down one after the other in the same line without any sign of equality being interposed. Thus the equations :

$$\sqrt{x+5}=s, \sqrt{x-7}=t$$

appear as

1. सद्दशदिवधो वर्गस्त्वादिवधस्तद् गतोऽन्यजातिवधः ।

अन्योऽन्यवर्णधातो भावितकः पूर्ववच्छेषम् ॥

2. *BrSpSi*. XVIII. 43 (com)

—*BrSpSi*. XVIII. 42.

$$\begin{array}{|c|c|c|c|c|} \hline 0 & 5 & yu & m\bar{u} & 0 \\ \hline 1 & 1 & & 1 & \\ \hline \end{array} \quad \begin{array}{|c|c|c|} \hline sa & 0 & 7 \\ \hline 1 & 1 & \\ \hline \end{array} + \begin{array}{|c|} \hline m\bar{u} & 0 \\ \hline 1 & \\ \hline \end{array}$$

Here *yu* (यु) stands for *yuta* (युत), meaning added, subtraction is + sign, derived from *Kṣaya* or (क्षय) meaning diminished, *gu* (गु) for *guṇa* or *guṇita*, meaning multiplied; *bhā* (भा) for division from *bhājita* and *mū* (मू) for square-root, from *mūla* meaning root; zero (०) was used to mark a vacant place.

Again, the following equation

$$x+2x+3\times 3x+12\times 4x=300$$

is represented as ;

$$\begin{array}{|c|c|c|c|c|c|} \hline 0 & 2 & 1 & 3 & 12 & 4 \\ \hline 1 & 1 & 1 & 1 & 1 & 1 \\ \hline \end{array} \quad dṛśya \ 300$$

There is no sign for unknown in the *Bakhaśālī Manuscript*.

Later on this plan of writing equations as adopted in *Bakhaśālī Manuscript* was abandoned in India; a new one was adopted in which the two sides are written one below the other without any sign of equality. It must be stated that in this new plan the term of similar denominations are usually written one below the other and even the terms of absent denominations on either side are clearly indicated by putting zeros as their coefficients. We find a reference to this new plan in the algebra of Brahmagupta.

From which the square of the unknown and the unknown are cleared, the known quantities are cleared (from the side) below that¹.

Here in this verse, the words “*adhastāt*” clearly indicate that one side of the equation is written below the other.. As an illustration, Pṛthūdaka Svāmi represented the equation² :—

$$10x-8=x^2+1$$

as :

$$y\bar{a} \ va \ 0 \ y\bar{a} \ 10 \ r\bar{u} \ \dot{8} \quad (x^2.0+x.10-8)$$

$$y\bar{a} \ va \ 1 \ y\bar{a} \ 0 \ r\bar{u} \ 1 \quad (x^2.1+x.0+1)$$

which means, x^2 was written as *yāvat-varga* (*yā va*) and x was written as *yāvat* or *yā*. The minus sign was represented by a dot at the top of the number. (—8 was written as $\dot{8}$). We shall take another illustration from Pṛthūdaka Svāmī.

He would write the equation

$$197x-1644 \ y-z=6302$$

as

1. *BrSpSi*. XVII. 43; compare also Bhāskara II, *Bijaganita*.

2. *BrSpSi*. XVIII. 49 (*com.*)

$$\begin{array}{rcccccccc} y\bar{a} & 197 & k\bar{a} & 1644 & n\bar{i} & 1 & r\bar{u} & 0 \\ y\bar{a} & 0 & k\bar{a} & 0 & n\bar{i} & 0 & r\bar{u} & 6302 \end{array}$$

Here the first unknown x is represented by $y\bar{a}(vat)$, the second unknown y by $k\bar{a}(laka)$ and the third unknown z by $n\bar{i}(laka)$ and the term without unknown, a mere number is written by $r\bar{u}(paka)$. The two sides, one written below the other if written in the present form, would appear as :

$$197x - 1644y - z + 0 = 0x + 0y + 0z + 6302.$$

The *Bijaganita* of Bhāskara II also follows the same procedure. One instance from it would be quoted here to illustrate the method of expressing equations.

$$8x^3 + 4x^2 + 10y^2x = 4x^3 + 12y^2x$$

$$\text{or } 8x^3 + 4x^2 + 10y^2x = 4x^3 + 0x^2 + 12y^2x$$

is written as follows on Bhāskara's or Brahmagupta's plan :

x^3 is *ghana* of $y\bar{a}vat$ (abbreviated as $y\bar{a} gha$)

x^2 is *varga* of $y\bar{a}vat$ (abbreviated as $y\bar{a} va$)

y^2 is *varga* of $k\bar{a}laka$ (abbreviated as $k\bar{a} va$)

the coefficients 10 and 12 are *bhāvita* (abbreviated as *bhā*).

The equation is :

$$y\bar{a} gha \ 8 \ y\bar{a} va \ 4 \ k\bar{a} va \ y\bar{a}. \ bhā \ 10$$

$$y\bar{a} gha \ 4 \ y\bar{a} va \ 0 \ k\bar{a} va \ y\bar{a}. \ bhā \ 12$$

Datta and Singh state that the use of the old plan of writing equations is sometimes met with in later works also. For instance, in the MS. of Pṛthūdaka Svāmī's commentary¹ on the *Brahmasphuṭasiddhānta*, an incomplete copy of which is preserved in the library of the Asiatic Society of Bengal (No. I B6), we find a statement of equations thus : "first side $y\bar{a}vargaḥ \ 1 \ y\bar{a}vakaḥ \ 200 \ r\bar{u} \ 0$; second side $y\bar{a}vargaḥ \ 0 \ y\bar{a}vakaḥ \ 0 \ r\bar{u} \ 1500$."

Śodhana or Clearance of an Equation

After *nyāsa* or statement of an equation, the operation to be performed is known as *sodhana* (clearance) or *samsodhana* (equi-clearance or complete clearance). The nature of this clearance varies according to the kind of equation. In the case of an equation in one unknown only, whether linear,

1. *BrSpSi*. XII. 15 (*com.*)

quadratic or of higher powers, one side of it is cleared of the unknowns of all denominations and the other side of it of the absolute terms, so that the equation is ultimately reduced to one of the form

$$ax^2+bx=c,$$

where a, b, c may be positive or negative; some of them may even be zero. Thus Brahmagupta observes :

From which the square of the unknown and the unknown are cleared, the known quantities (*rūpāṇi*) are cleared (from the side) *below* that.¹

On this *Prthūdaka Svāmi* comments as follows :

This rule has been introduced for that case in which the two sides of the equation having been formed in accordance with the statement of the problem, there are present the square and other powers of the unknown together with the (simple) unknown. The absolute terms should be cleared off from the side opposite to that from which are cleared the square (and other powers) of the unknown and the (simple) unknown. When perfect clearance (*samsodhana*) has been thus made...²

Śrīdhara and Bhāskara II have also given the rules of clearance almost on the same lines. Thus the equation

$$yā\ va\ 0\ yā\ 10\ rā\ 8$$

$$yā\ va\ 1\ yā\ 0\ rā\ 1$$

after perfect clearance having been made will be (according to *Prthūdaka Svāmi*)

$$yā\ va\ 1\ yā\ 10\ rā\ 9$$

i.e. the equation $10x-8=x^2+1$

after clearance would become

$$x^2-10x=-9.$$

Classification of Equations

Usually equations are classified as :

simple equation : *yāvat-tāvat*

quadratic : *varga*

1. कर्मान्यन्ताः शोभ्या यस्माद् रूपाणि तदयस्तात् ॥

2. *BrSpSi*. XVIII. 43 (*com.*)

cubic : *ghana*
 biquadratic : *varga-varga*

Brahmagupta classified them as

- (i) equations in one unknown quantity : *eka-varṇa samīkaraṇa*.
- (ii) equations in several unknowns : *aneka-varṇa samīkaraṇa*.
- (iii) equations involving products of unknowns : *bhāvita*.

Eka-varṇa samīkaraṇas (equations with one unknown) are further divided into (i) linear equations, and (ii) quadratic equations (*avyakta-varga samīkaraṇa*).

Prthūdaka Svāmī has classified equations in a different manner as follows :

- (i) linear equations with one unknown : *eka-varṇa samīkaraṇa*.
- (ii) linear equations with more unknowns : *aneka-varṇa samīkaraṇa*.
- (iii) equations with one, two or more unknowns in their second or higher powers : *madhyamāharaṇa*.
- (iv) equations involving products of unknowns : *bhāvita*.

As the method of solution of an equation of the third class (i.e. equations with one or several unknowns in their second or higher powers) is based upon the principle of the elimination of the middle term, that class is called by the term *madhyama* (middle) *āharaṇa* (elimination). The classification of Brahmagupta and Prthūdaka Svāmī more or less received recognition by later writers on algebra as Bhāskara II and others.

Linear Equations with One Unknown and Their Solutions

The first solution of a linear equation with one unknown is obtainable in the *Śulba Sūtras* but not through an algebraic process,—the *Śulba* process is geometrical. It is said that there is a reference in the *Sthānāṅga Sūtra* (c. 300 B.C.) to a linear equation by its name *yavat-tāvat*. There has been a good deal of

controversy regarding the date of the *Bakhaṣālī Manuscript* where we have definitely a method of solving linear equations by the *Rule of False Position*. It would be interesting to give an account of this rule here by taking an illustration from the *Bakhaṣālī Manuscript*.

Problem :

The amount given to the first is not known. The second is given twice as much as the first; the third thrice as much as the second; and the fourth four times as much as the third. The total amount distributed is 132. What is the amount of the first ?

(BMS. Folio 23, recto)

In modern algebraic language, the solution of the problem would be given by the equation

$$x + 2x + 6x + 24x = 132$$

where x is the amount given to the first.

The solution of this equation is given as follows in the *Bakhaṣālī Manuscript* :

'Putting any desired quantity in the vacant place'; any desired quantity is $\parallel 1 \parallel$, 'then construct the series'

$$\begin{array}{|c|c|c|c|c|c|c|} \hline 1 & 2 & 2 & 3 & 6 & 4 \\ \hline 1 & 1 & 1 & 1 & 1 & 1 \\ \hline \end{array}$$

'multiplied' $\parallel 1 \parallel 2 \parallel 6 \parallel 24 \parallel$; 'added' 33. 'Divide the visible quantity' $\parallel \begin{array}{c} 132 \\ 33 \end{array} \parallel$; which) on reduction be-

comes $\parallel \begin{array}{c} 4 \\ 1 \end{array} \parallel$. (This is) the amount given (to the first)

(BMS. Folio 23, recto)

The Rule of False Position may be regarded as an early stage of the development of the science of algebra, since no symbol could have been evolved for an unknown quantity. As soon as the system of notations was introduced, the application of this Rule was no longer considered as necessary. Thus we find that Āryabhaṭa I does not mention of this Rule.

Āryabhaṭa I states as follows regarding the solution of linear equations :

The difference of the known 'amounts' (*rūpaka*) relating to two persons should be divided by the difference

of the coefficients on the unknown (*gulika*). The quotient will be the value of the unknown (*gulika*), if their possessions be equal.¹

The original verse contains the term "*gulikāntara*" which has been here translated as the difference of the coefficients of the unknowns. We have already stated earlier that Āryabhaṭa uses the term *gulika* or shot for an unknown quantity. (*gulikāntara* literally means only the difference of unknowns). This practice is also followed by other Indian algebraists. Pṛthudaka Svāmī rightly observed that according to the usual practice in this country, 'the coefficient of the square of the unknown is called the square (of the unknown) and the coefficient of the (simple) unknown is called the unknown.'²

The rule given by Āryabhaṭa, then, contemplates a problem of this kind :

Two persons, who are equally rich, possess respectively a, b times a certain unknown amount together with c, d units of money in cash. What is that amount ?

Now if x be the amount unknown, then according to the problem

$$ax + c = bx + d$$

Thence

$$x = \frac{d-c}{a-b}$$

Āryabhaṭa has merely expressed this solution in his language.

Regarding the solution of linear equations, Brahmagupta says :

In a (linear) equation in one unknown, the difference of the known terms taken in the reverse order, divided by the difference of the coefficients of the unknown (is the value of the unknown).³

1. गुलिकान्तरेण विभजेद् द्वयोः पुरुषयोस्तु रूपकविशेषम् ।
लब्धं गुणिकामूल्यं यद्यर्थं कृतं भवति तुल्यम् ॥

—Ārya. II. 30

2. BrSpSi, XVIII. 44 (com.)

3. अव्यक्तान्तरभक्तं व्यस्तं रूपान्तरं समेऽव्यक्तः ।
वर्गाव्यक्ताः शोभ्या यस्माद् रूपाणि तदधस्तात् ॥

—BrSpSi. XVIII. 43

Similar solutions have been offered by the other Indian algebraists who followed Brahmagupta like Śrīpati, Bhāskara II and Nārāyaṇa. Here again, we take a problem proposed by Brahmagupta in this connection :

Problem :

Tell the number of elapsed days for the time when four times the twelfth part of the residual degrees increased by one, plus eight will be equal to the residual degrees plus one.¹

Prthūdaka Svāmī has solved this problem as follows :

Here the residual degrees are (put as) $yāvat-tāvat$, $yā$; increased by one, $yā\ 1\ rū\ 1$; twelfth part of it, $\frac{yā\ 1\ rū\ 1}{12}$; four times this, $\frac{yā\ 1\ rū\ 1}{3}$; plus the absolute quantity eight, $\frac{yā\ 1\ rū\ 25}{3}$. This is equal to the residual degrees plus unity. The statement of both sides tripled is

$$\begin{array}{cc} yā\ 1 & rū\ 25 \\ yā\ 3 & rū\ 3 \end{array}$$

This difference between the coefficients of the unknown is 2. By this the difference of the absolute terms, namely 22, being divided, is produced the residual of the degrees of the Sun, 11. These residual degrees should be known to be irreducible. The elapsed days can be deduced then, (proceeding) as before.

If put in the modern notations, it means the solution of the equation :

$$\frac{4}{12}(x+1)+8=x+1,$$

from which we have

$$x+25=3x+3$$

or

$$2x=22$$

or

$$x=11.$$

Rule of Concurrence or Saṁkramaṇa

Brahmagupta has included this rule in algebra, whereas other Indian mathematicians included it in arithmetic. *Sam-*

1. सैकादशरोषाद् द्वादशमागश्चतुर्गुणोऽष्टयुतः ।

सैकादशरोषतुल्यो यदा तदाऽहर्गणं कथय ॥

kramana is the solution of the simultaneous equations of the type :

$$x+y=a$$

$$x-y=b$$

Brahmagupta's rule for solution is:

The sum is increased and diminished by the difference and divided by two; (the result will be the two unknown quantities): (this is) concurrence (*Samkramana*).¹

Brahmagupta restates this rule in the form of a problem and its solution :

The sum and difference of the residues of two (heavenly bodies) are known in degrees and minutes. What are the residues? The difference is both added to and subtracted from the sum, and halved; (the results are) the residues.²

Linear Equations with Several Unknowns

The first mention of a solution of the problem with more than one unknown is found in the *Bakhsāli Manuscript*, and a system of linear equations of this type is solved in the *Bakhsāli* treatise substantially by the False Position Rule.

A generalised system of linear equations will be

$$b_1 \sum x - c_1 x_1 = a_1, b_2 \sum x - c_2 x_2 = a_2, \dots, b_n \sum x - c_n x_n = a_n$$

$$b_n \sum x - c_n x_n = a_n$$

Therefore

$$\sum x = \frac{\sum(a/c)}{\sum(b/c) - 1}$$

Hence

$$x_r = \frac{b_r}{c_r} \times \frac{\sum(a/c)}{\sum(b/c) - 1} - \frac{a_r}{c_r}$$

$r=1, 2, 3, \dots, n$

One particular case, where $b_1=b_2=b_3=\dots=b_n=1$ and $c_1=c_2=c_3=\dots=c_n=c$ has been treated by Brahmagupta at one place. He gives the rule as follows :

1. योगोऽन्तरयुतहीनो दिहृतः संक्रमणमन्तरविभक्तं वा ।

वर्गान्तरमन्तरयुतहीनं दिहृतं विषयकर्म ॥

— *BrSpSi. XVIII. 36*

2. भागकला विकलेक्यं दृष्ट्वा विकलान्तरं च के शेषे ।

ऐक्यं दिधाऽन्तराधिक हीनं च दिभाजितं शेषे ॥

— *BrSpSi. XI'VIII. 96*

The total value (of the unknown quantities) plus or minus the individual values (of the unknowns) multiplied by an optional number being severally (given), the sum (of the given quantities) divided by the number of unknowns increased or decreased by the multiplier will be the total value; thence the rest (can be determined).¹

$$\begin{aligned}\Sigma x \pm cx_1 &= a_1, \Sigma x \pm cx_2 = a_2, \Sigma x \pm cx_3 = a_3, \dots, \\ \Sigma x \pm cx &= a_n\end{aligned}$$

Therefore

$$\Sigma x = \frac{a_1 + a_2 + a_3 + \dots + a_n}{n \pm c}$$

Hence

$$x_1 = \frac{1}{c} \left(\pm a_1 \mp \frac{a_1 + a_2 + a_3 + \dots + a_n}{n \pm c} \right);$$

and so on for x_2, x_3 etc.

Now we shall give the rule enunciated by Brahmagupta for solving linear equations involving several unknowns :

Removing the other unknowns from (the side of) the first unknown and dividing by the coefficient of the first unknown, the value of the first unknown (is obtained). In the case of more (values of the first unknown), two and two (of them) should be considered after reducing them to comon denominators. And (so on) repeatedly. If more unknowns remain (in the final equation), the method of the pulveriser (should be employed). (Then proceeding) reversely (the values of other unknowns can be found).²

Prthudaka Svāmi has commented on this rule as follows :

In an example in which there are two or more unknown quantities, colours such as *yāvat-tāvat*, etc., should be assumed for their values. Upon them should

1. गञ्चधनमिष्ट गुणितैर्धनैषु तोनं पृथक् पृथक् सहितम् ।

गुणकयुतेन पदहतं सर्वधनमतोऽवशेषाणि ॥

—*BrSpSi*: XIII. 47

2. आधादकर्णान्यान् वर्णान् प्रो ह्यवमानमाद्यहतम् ।

सदृशच्येदावसकृद् द्वौ व्यस्तौ कुट्टको बहुषु ॥

—*BrSpSi*: XVIII. 51

be performed all operations conformably to the statement of the example and thus should be carefully framed two or more sides and also equations. Equi-clearance should be made first between two and two of them and so on to the last: from one side one unknown should be cleared, other unknowns reduced to a common denominator and also the absolute numbers should be cleared from the side opposite. The residue of other unknowns being divided by the residual coefficient of the first unknown will give the value of the first unknown. If there be obtained several such values, then with two and two of them, equations should be formed after reduction to common denominators. Proceeding in this way to the end find out the value of one unknown. If that value be (in terms of) another unknown then the coefficients of those two will be reciprocally the values of the two unknowns. If, however, there be present more unknowns in that value, the method of the pulveriser should be employed. Arbitrary values may then be assumed for some of the unknowns.

Datta and Singh have said that the above rule of Brahmagupta, and also the one indicated in the commentary of Pṛthudaka Svāmī, embraces the solution of indeterminate as well as the determinate equations. In fact, all the examples given by Brahmagupta in illustration of the rule are of indeterminate character. So far as the determinate simultaneous equations are concerned, Brahmagupta's method for solving them will be easily recognised to be the same as our present one.

Quadratic Equations

The geometrical solution of a quadratic equation in this country would take us to the Vedic Śulba period. The *Bakṣasāli Manuscript* also contains certain problems which need the solving of quadratic equations. I shall quote one out of the numerous available:

A certain person travels s *yojana* on the first day and b *yojana* more on each successive day. Another, who travels at the uniform rate of S *yojana* per day, has a start of t days. When will the first man overtake the second?

This problem would today be expressed in terms of the following equation :

$$S(t+x)=x\left\{s+\left(\frac{x-1}{2}\right)b\right\},$$

where x is the number of days after which the first overtakes the second. We may write this equation as

$$bx^2 - \{2(S-s)+b\}x = 2tS$$

whence the value x would be after solving the quadratic :

$$x = \frac{\sqrt{\{2(S-s)+b\}^2 + 8bts} + \{2(S-s)+b\}}{2b}$$

The *Bakhasālī Manuscript* gives this solution as follows :

The daily travel (S) diminished by the march of the first day (s) is doubled; this is increased by the common increment (b). That (*sum*) multiplied by itself is designated (as the *kṣepa* quantity). The product of the daily travel and the start (t) being multiplied by eight times the common increment, the *kṣepa* quantity is added. The square-root of this (is increased by the *kṣepa* quantity; the sum divided by twice the common increment will give the required number of days), (*BMS. Folio 5, recto*)

Āryabhaṭa I (499 A.D.) is regarded as the founder of algebra, since he gives the solutions of a few quadratic problems. For example, to find the number of terms of an arithmetical progression (A.P.), he gives the following rule :

The sum of the series multiplied by eight times the common difference is added by the square of the difference between twice the first term and the common difference: the square-root (of the result) is diminished by twice the first term and (then) divided by the common difference : half of this quotient plus unity is the number of terms.¹

In the modern notations of algebra, the solution would be expressed as follows :

1. गच्छोऽष्टोत्तर गुणिताद् द्विगुणाद्युत्तर विशेषवर्गयुतात् ।

मूलं द्विगुणाद्यूनं स्वीत्तर भजितं सरूपार्थं ॥

$$n = \frac{1}{2} \left\{ \frac{\sqrt{8bs + (2a-b)^2} - 2a}{b} + 1 \right\}$$

There is another certain interest problem¹, the solution of which has been provided in the *Āryabhaṭīya* as

$$x = \frac{\sqrt{Apt + (p/2)^2} - p/2}{t}$$

which is the solution of the quadratic equation :

$$tx^2 + px - Ap = 0$$

Āryabhaṭa I has thus given the solutions of a few quadratic equations, but he nowhere gives the procedure of solving these equations.

We give here the Rules of Brahmagupta for the solution of quadratic equations. He undoubtedly is not the discoverer of these rules; but perhaps for the first time in the history of algebra we find the process of solving a quadratic equation so clearly indicated.

First Rule :

The quadratic : the absolute quantities multiplied by four times the coefficient of the square of the unknown are increased by the square of the coefficient of the middle (i.e. unknown); the square-root of the result being diminished by the coefficient of the middle and divided by twice the coefficient of the square of the unknown, is (the value of) the middle."²

This expressed in the modern notations would mean

$$x = \frac{\sqrt{4ac + b^2} - b}{2a}$$

It would be noted that in this rule, Brahmagupta has employed the term *madhya* (middle) to imply the simple unknown as well as its coefficient. The origin of the term is doubtless connected with the mode of writing the quadratic equation in the form

$$ax^2 + bx + 0 = 0x^2 + 0x + c$$

so that there are three terms on each side of the equation.

1. मूलफलं सफलं कालमूलं गुणमर्धमूलं कृति युक्तम् ।

मूलं मूलार्धेन कालहृतं स्यात्स्वमूलफलम् ॥

—*Ārya. II. 25.*

2. वर्गं चतुर्गुणितानां रूपाणां मध्यवर्गसहितानाम् ।

मूलं मध्यनोनं वर्गं द्विगुणोद्धृतं मध्यः ॥

—*BrSpSi. XVIII. 44.*

Second Rule :

The absolute term multiplied by the coefficient of the square of the unknown is increased by the square of half the coefficient of the unknown; the square-root of the result diminished by half the coefficient of the unknown and divided by the coefficient of the square of the unknown is the unknown.²

This when expressed in the modern algebraic notations would be

$$x = \frac{\sqrt{ac + (b/2)^2} - (b/2)}{a}$$

Here if the quadratic equation is

$$ax^2 + bx + c = 0$$

the 'absolute term' is c (the one without the unknown x), 'the coefficient of the square of unknown' means the coefficient of x^2 , i.e. a , and the 'coefficient of the unknown' means the coefficient of x , i.e. b .

The above two methods of Brahmagupta are exactly the same as were suggested by Āryabhaṭa I.

The root of the quadratic equation for the number of terms of an arithmetic progression (A.P.) is given by Brahmagupta according to the first rule² :

$$n = \frac{\sqrt{8bs + (2a - b)^2} - (2a - b)}{2b}$$

Third Rule :

Brahmagupta also suggests a Third Rule which is very much the same as is used commonly now. Though it has not been expressly suggested as a new rule, we find its application in a few instances. For example this rule has been suggested in connection with the following problem on interest :

A certain sum (p) is lent out for a period (t_1); the interest accrued (x) is lent out again at this

1. वर्गादित रूपार्यामव्यक्तार्थकृति संयुतानां यत् ।

पदमव्यक्तार्थोनं तद्वर्गं विभक्तमव्यक्तः ॥

—BrSpSi. XVIII. 45

2. उत्तरहीनदिगुणादि शेषवर्गं धनोत्तराष्टववे ।

अद्विष्य पदं शेषोनं दिगुणोत्तरहसं गच्छः ॥

—BrSpSi. XII. 18

rate of interest for another period (t_2) and the total amount is A . Find x .

The equation for determining x is

$$\frac{t_2}{pt_1}x^2 + x = A.$$

The solution of this equation would be :

$$x = \sqrt{\left(\frac{pt_1}{2t_2}\right)^2 + \frac{A}{t_2}} - \frac{pt_1}{2t_2}$$

Brahmagupta has stated the result in exactly the same form. Pṛthudaka Svāmī has illustrated it in solving the following problem of interest :

Problem :

A sum of five hundred *paṇas* (p) is lent out for a period of 4 months (t_1); the interest accrued (x) is lent out again at this rate of interest for another period of 10 months (t_2) and the total amount is 78 (A). Give the *pramāṇa-phala*, i.e., the interest accrued x .

Here *pramāṇa-kāla* (t_1) = 4 months

pramāṇa-dhana (p) = 500 *paṇas*

para-kāla (t_2), the subsequent period = 10 months

miśra dhana or the total interest accrued (A) = 78 *paṇas*.

Brahmagupta states his solution of such quadratics like this :

Take the product of the *pramāṇa-dhana* (p) or the sum originally lent out and *pramāṇa-kāla*, i.e. the period for which originally lent out (t_1); and divide by the *para-kāla* or the subsequent time (t_2); place this result at two places. Multiply the one placed at the first place with the *miśra-dhana* (A), that is with the total interest accrued; in this product add the square of half the one placed in the second place; now take the square-root of it, and from it subtract half of the one placed at the second place.¹

1. कालप्रमाणधनः परकालद्वयो द्विधाऽऽवमिश्रवधात् ।

अन्वार्धकृति युतात् पदमन्वार्धेन प्रमाय फलम् ॥

—BrSpSi. XII. 15:

Thus in the above example the product of *pramāṇa-dhana* and *pramāṇa kālā* divided by *parakālā* is (pt_1/t_2) is $\frac{500 \times 4}{10} = 200$.

This is first multiplied by the total interest accrued (A); it becomes $200 \times 78 = 15600$. To this is now added square of half of 200 (which is 10000); it becomes 15600 plus 10000 = 25600. Its square-root is taken which is 160. From this is subtracted half of the quantity (i.e. half of 200 which is 100). Thus $160 - 100 = 60$, which is the answer. It was the interest which first accrued (x).

... *Another Quadratic Problem:*

Brahmagupta refers to an astronomical problem which involves the quadratic equation

$$(72 + a^2)x^2 \mp 24apx = 144\left(\frac{R^2}{2} - p^2\right),$$

where $a = \text{agra}$ (the sine of the amplitude of the Sun), $b = \text{palabha}$ (the equinoctial shadow of a gnomon 12 anguli long), $R = \text{radius}$, and $x = \text{koṣaśaṅku}$ (sine of the altitude of the Sun when his altitude is 45°). Dividing out by $(72 + a^2)$ we have

$$x^2 \mp 2mx = n,$$

where

$$m = \frac{12ap}{72 + a^2}, \quad n = \frac{144(R^2/2 - p^2)}{72 + a^2}.$$

Therefore we have

$$x = \sqrt{m^2 + n} \pm m,$$

as stated by Brahmagupta. We find the same result in the *Sūrya-siddhānta* and in the text of Śrīpati. Āryabhaṭa II (1150) also followed the method of Āryabhaṭa I and Brahmagupta in solving a quadratic equation in connection with finding out the number of terms in an arithmetical progression (A.P.) whose first term is (a) , common difference is b and the sum is s . The number of terms n is given by¹

$$n = \frac{\sqrt{2bs + (a - b/2)^2} - a + b/2}{b}$$

Two Roots of a Quadratic Equation and Brahmagupta

A quadratic equation has two roots. This must have been known to Indian algebraists even at a very early stage. Bhāskara II in his *Bījaganita* has quoted a rule ascribed to an ancient writer Padmanābha whose works are not available now :

1. *Mahāsiddhānta*, Bhāskara II, XV. 50

If (after extracting roots) the square-root of the absolute side (of the quadratic) be less than the negative absolute term on the other side, then taking it negative as well as positive two values (of the unknown) are found¹.

The term used here is *dvividhotpadyate mitih* which means that two values are obtained.

The existence of two roots of a quadratic equation appears to have been known also to Brahmagupta (628 A.D.). In illustration of his rules for the solution of a quadratic he has stated two problems involving practically the same equation :

Problem I : The square-root of the residue of the revolution of the Sun less 2 is diminished by 1, multiplied by 10 and added by 2; when will this be equal to the residue of the revolution of the Sun less 1, on Wednesday ?²

Problem II : When will the square of one-fourth the residue of the exceeding months less three, be equal to the residue of the exceeding months ?

We shall follow Pṛthūdaka Svāmi in solving the Problem I. In this problem the residue of the revolutions of the Sun may be supposed to be x^2+2 ; then by the question, we have

$$10(x-1)+2=x^2+1,$$

$$\text{or } x^2-10x=-9$$

Again in Problem II, if we put $4x$ for the residue of the exceeding month, then we have

$$(x-3)^2=4x$$

$$\text{or } x^2-10x=-9,$$

Now by the second rule of Brahmagupta, retaining both the signs of the radical, we get :

$$x=5\pm\sqrt{25-9}=9 \text{ or } 1,$$

1. व्यक्त पक्षस्य चेन्मूलमन्यपक्षरूपतः ।

अल्पं धनर्यगं कृत्वा द्विविधोत्पद्यते मितिः ॥

—Bhāskara, *Bījaganita*

2. मण्डलशेषाद् द्वयूनान्मूलं व्येकं दशाहतं द्वियुतम् ।

मण्डलशेषं व्येकं भानोर्द्विदिने कदा भवति ॥

—BrSpSi. XVIII. 49

3. अधिमासशेषपादात् व्यूनाद्वर्गोऽधिमासशेषसमः ।

अवंमावर्शेषतो वावमशेषसमः कदा भवति ॥

—BrSpSi. XVIII. 50.

As shown by Pṛthūdaka Svāmī, the first value is taken by Brahmagupta for the Problem I and second value for the problem II. Thus it is quite clear that Brahmagupta uses sometimes the positive and at other times the negative sign with the radical. Hence we shall say that Brahmagupta knew that a quadratic equation would have two roots, and according to the requisiteness of the problem, one value out of the two would be utilised.

Simultaneous Quadratic Equations

Indian authors usually treated problems involving various forms of simultaneous quadratic equations.

$$\begin{array}{ll} \text{(i)} \quad \left. \begin{array}{l} x-y=d \\ xy=b \end{array} \right\} & \text{(ii)} \quad \left. \begin{array}{l} x+y=a \\ xy=b \end{array} \right\} \\ \text{(iii)} \quad \left. \begin{array}{l} x^2+y^2=c \\ xy=b \end{array} \right\} & \text{(iv)} \quad \left. \begin{array}{l} x^2+y^2=c \\ x+y=a \end{array} \right\} \end{array}$$

For the solution of the combination (i), Āryabhaṭa I gives the following rule in his *Āryabhaṭīya*.

The square-root of four times the product (of two quantities) added with the square of their difference, being added and diminished by their difference and halved gives the two multiplicands.¹

This means that

$$x = \frac{1}{2} \sqrt{d^2 + 4b} + d, \quad y = \frac{1}{2} (\sqrt{d^2 + 4b} - d)$$

For the solution of the same combination, Brahmagupta states as follows :

The square-root of the sum of the square of the difference of the residues and two squared times the product of the residues, being added and subtracted by the difference of the residues, and halved (gives) the desired residues severally.²

(Here by difference of the residues is meant $x-y$; and by product of the residues is meant xy .)

Brahmagupta does not seem to give the solution for simultaneous equations of the combination (ii). Mahāvīra (850 A.D.)

1. द्विकृति गुणात्संवर्गाद् द्वयन्तरवर्गेण संयुतान्मूलम् ।

अन्तरयुक्तं हीनं तद्गुणकारद्वयं दलितम् ॥

—Ārya. II. 24

2. शेषवद् द्वि कृति गुणात् शेषान्तरं कौ संयुतान्मूलम् ।

शेषान्तरेण युक्तं दलितं शेषे पृथगभीष्टे ॥

—Br SpSi. XVIII. 99

has given the solution :

Subtract four times the area (of a rectangle) from the square of the semi-perimeter then by *sankramaṇa* between the square-root of that (remainder) and the semi-perimeter, the base and the upright are obtained.¹ (GSS. VII. 129 $\frac{1}{2}$)

This expressed in the modern notations would be :

$$x = \frac{1}{2}(a + \sqrt{a^2 - 4b}), y = \frac{1}{2}(a - \sqrt{a^2 - 4b})$$

For the combination (iii), Mahāvīra in his *Gaṇita-Sāra-Saṃgraha* gives the following rule :

Add to and subtract twice the area (of a rectangle) from the square of the diagonal and extract the square-roots. By *sankramaṇa* between the greater and lesser of these (roots), the side and upright (are found).²

This put in modern notations would be :

$$x = \frac{1}{2}(\sqrt{c+2b} + \sqrt{c-2b}),$$

$$y = \frac{1}{2}(\sqrt{c+2b} - \sqrt{c-2b}).$$

For the combination (iv), Āryabhaṭa I gives the following rule :

From the square of the sum (of two quantities) subtract the sum of their squares. Half of the remainder is their product.³

The remaining operations will be similar to those for the equations (ii); so that

$$x = \frac{1}{2}(a + \sqrt{2c - a^2}), y = \frac{1}{2}(a - \sqrt{2c - a^2}).$$

Brahmagupta in this connection says :

Subtract the square of the sum from twice the sum of squares; the square-root of the remainder being added to and subtracted from the sum and halved, (gives) the desired residues.⁴

1. GSS. VII. 129 $\frac{1}{2}$

2. GSS. VII. 127 $\frac{1}{2}$

3. संपर्कस्य हि वर्गद्विशोधयेदेव वर्गसंपर्कम् ।

यत्तस्य भवत्यर्थं विद्याद् गुणकारसंपर्कम् ॥

—Ārya. II. 23

4. कृति संयोगाद् दिगुण्याद्युतिं वर्गं प्रोह्य शेष मूलं यत् ।

तेन युतो नो योगो दलितः शेषे पृथगभीष्टे ॥

—BrSpSi. XVIII. 98

These equations have also been treated by Mahāvīra, Bhāskara II and Nārāyaṇa. Nārāyaṇa has attempted two other forms of quadratic equations :

$$(v) \begin{cases} x^2 + y^2 = c \\ x - y = d \end{cases} \quad (vi) \begin{cases} x^2 - y^2 = m \\ xy = b \end{cases}$$

For their solutions, see Datta and Singh, *Algebra*, P. 84.

Rule of Dissimilar Operations :

Datta and Singh say that the process of solving the following two particular cases of simultaneous quadratic equations was distinguished by most Indian mathematicians by the special designation *viśama-karma* or dissimilar operation :

$$(i) \begin{cases} x^2 - y^2 = m \\ x - y = n \end{cases} \quad (ii) \begin{cases} x^2 - y^2 = m \\ x + y = p \end{cases}$$

These equations have been regarded by these mathematicians as if of fundamental importance. They have given the following solutions (expressed in modern algebraic symbols) :

For the combination (i) :

$$x = \frac{1}{2} \left(\frac{m}{n} + n \right), y = \frac{1}{2} \left(\frac{m}{n} - n \right),$$

For the combination (ii) :

$$x = \frac{1}{2} \left(p + \frac{m}{p} \right), y = \frac{1}{2} \left(p - \frac{m}{p} \right).$$

We shall express these solutions as follows in the words of Brahmagupta :

The difference of the squares (of the unknowns) is divided by the difference of the unknowns and the quotient is increased and diminished by the difference and divided by two ; (the results will be the two unknown quantities) ; (this is) dissimilar operation.

The same rule is restated by him on a different occasion in the course of solving a problem.

If then the difference of their squares, also the difference of them (are given) ; the difference of the squares

1. योगोऽन्तरयुतहीनो दिहतिः संक्रमणमन्तर विभक्तं वा ।
३. संक्रान्तमन्तरयुतहीनं दिहति विषयकर्म ।

is divided by the difference of them, and this (latter) is added to and subtracted from the quotient and then divided by two ; (the results are) the residues whence the number of elapsed days (can be found).¹

This *viṣama-karma* or dissimilar operation has been described by other Indian algebraists also, as Āryabhaṭa II (*Mahāśi-
ddhantā*, XVII; 22); Śrīpati (*Siddhantā-sekhara*, XIV. 13) ; Bhā-
skara II (*Līlavatī*) and Nārāyaṇa (*Gaṇita-kaumudī*, I, 32).

Indeterminate Equations of the First Degree

Āryabhaṭa I should be given the credit of giving for the first time a treatment of the indeterminate equation of the first degree. In his *Āryabhaṭīya*, we find a method for obtaining the general solution in positive integers of the simple indeterminate equation :

$$by - ax = c$$

for integral values of a, b, c , and further indicated how to extend it to get positive integral solutions of simultaneous indeterminate equations of the first degree. His disciple Bhāskara I (522) showed that the same method might be applied to solve :

$$by - ax = -c$$

and further that the solution of this equation would follow that of $by - ax = -1$. These methods of Āryabhaṭa I and Bhāskara I have also been adopted by Brahmagupta, and in certain cases, the improvement were suggested by Āryabhaṭa II in the middle of the tenth century A.D.

The problems which were treated by ancient Indian algebraists and which led them to the investigation of the simple indeterminate equation of the first degree may be classified under three heads :

Class I : To find a number N which being divided by two given numbers (a, b) will leave two given remainders (R_1, R_2).

Thus we have :

$$N = ax + R_1 = by + R_2$$

1. तद्वर्गान्तरमाद्ये तदन्तरं चान्तरोदधृतयुतोन्म ।
वर्गान्तरं विभक्तं द्वान्यां शेषे ततोद्युगलः ।

Hence * $by - ax = R_1 - R_2$

Putting $c = R_1 \cup R_2$

we get $by - ax = \pm c$

the upper or lower sign being taken according as R_1 is greater than or less than R_2 .

Class II : To find a number (x) such that its product with a given number (a) being increased or decreased by another given number (δ) and then divided by a third given number (β) will leave no remainder.

This means that in other words, we shall have to get the solution of :

$$\frac{ax \pm r}{\beta} = y$$

in positive integers.

Class III : Here we have to deal with an equation of the form :

$$by \div ax = \pm c$$

Kuṭṭaka, *Kuṭṭākāra* and *Kuṭṭa* : These are the three terms which Brahmagupta has used in regards to the subject of indeterminate analysis of the first degree. Āryabhaṭa I has also described this method in brief, but he does not use the word *kuṭṭaka*. In the *Mahābhāskarīya* of Bhāskara I we have the terms *kuṭṭākāra* and *kuṭṭa* (522 A.D.) *MBh.* I. 41.49). These words have been translated into English as *pulveriser* or *grinder*. According to Datta and Singh, the Hindu method of solving the equation $by - ax = \pm c$ is essentially based on a process of deriving from it successively other similar equations in which the values of the coefficients (a, b) become smaller and smaller. Thus the process is indeed the same as that of breaking a whole thing into smaller pieces, and this accounts for its name *kuṭṭaka* or 'pulveriser'.

In the problems of the Class I, the quantities (a and b) are called 'divisors' (*bhāgahāra*, *bhājaka*, *cheda* etc.) and R_1 and R_2 as 'remainders' (*agra* or *śeṣa* etc.). while in a problem of the Class II; β is ordinarily called the 'divisor' (*bhāgahāra* or *bhājaka*) and γ the 'interpolator' (*kṣepa*, *kṣepaka* etc.) ; here a is called the 'dividend' (*bhājya*), the unknown quantity to be found (x) is called the 'multiplier' or (*guṇaka* or *guṇakāra* etc) and y the

quotient or *phala*. In later years, Mahāvīra has called the unknown number (x) as *rāśi*.

Preliminary Operations
in Kuṭṭaka-Karma

Usually it has been suggested that in order that an equation of the form

$$by - ax = \pm c \text{ or } by + ax = \pm c$$

may be amenable to solution, the two numbers a and b must not have a common divisor; for otherwise, the equation would be absurd, unless the number c had the same common divisor. So before the rules which we shall give hereafter, could be applied, the numbers a, b, c must be made prime (*dydha* or firm; *niccheda* or having no divisor, or *nirapavarta*, meaning irreducible to each other.

In this connection Bhāskara I writes :

The dividend and divisor will become prime to each other on being divided by the residue of their mutual division. The operation of the pulveriser should be considered in relation to them.¹

Similarly we find in the writings of Brahmagupta :

Divide the multiplier and the divisor mutually and find the last residue; those quantities being divided by the residue will be prime to each other.²

Āryabhaṭa's Rule : Āryabhaṭa I is probably the first Indian writer on this subject, but the operation given by him is rather obscure. His disciple Bhāskara I has given the solution of indeterminate equations of the first degree in more satisfactory language. We shall give here the translation of Āryabhaṭa's verse from the *Āryabhaṭaśya*, as rendered by Bibhutibhusan Datta, because other translations of this verse do very often confuse the sense :

Divide the divisor corresponding to the greater remainder by the divisor corresponding to the smaller remain-

1. भूदिनेष्टगणान्योन्य भक्तशेषेण भाजितौ ।

हारभाज्यौ ह्रदौ स्यातां कुट्टाकारं तवोर्विदुः

2. हृतयोः परस्परं यच्चेष्टं गुणकारभागहारकयोः ।

तेन हृतौ निश्छेदौ तावेव परस्परं हृतयोः ।

—MBh, I. 41

—BrSpSi, XVIII. 9.

Hence $by - ax = R_1 - R_2$

Putting $c = R_1 \cup R_2$

we get $by - ax = \pm c$

the upper or lower sign being taken according as R_1 is greater than or less than R_2 .

Class II : To find a number (x) such that its product with a given number (a) being increased or decreased by another given number (δ) and then divided by a third given number (β) will leave no remainder.

This means that in other words, we shall have to get the solution of :

$$\frac{ax \pm r}{\beta} = y$$

in positive integers.

Class III : Here we have to deal with an equation of the form :

$$by \div ax = \pm c$$

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quotient or *phala*. In later years, Mahāvīra has called the unknown number (x) as *rāsi*.

Preliminary Operations in Kuṭṭaka-Karma

Usually it has been suggested that in order that an equation of the form

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—MBh. I. 41

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तेन हृतौ निश्छेदौ तावेव परस्परं हृतयोः ।

—BrSpSi. XVIII. 9.

der. The residue (and the divisor corresponding to the smaller remainder) being mutually divided, the last residue should be multiplied by such an optional integer that the product being added (in case the number of quotients of the mutual division is even) or subtracted (in case the number of quotients is odd) by the difference of the remainders (will be exactly divisible by the last but one remainder. Place the quotients of the mutual division successively one below the other in a column; below them the optional multiplier and underneath it the quotient just obtained). Any number below the penultimate) is multiplied by the one just above it and then added by that just below it. Divide the last number (obtained by doing so repeatedly) by the divisor corresponding to the smaller remainder; then multiply the residue by the divisor corresponding to the greater remainder and add the greater remainder. (The result will be) the number corresponding to the two divisors.¹

There is an alternative rendering of this passage also as follows :

Divide the divisor corresponding to the greater remainder by the divisor corresponding to the smaller remainder. The residue (and the divisor corresponding to the smaller remainder) being mutually divided (until the remainder becomes zero), the last quotient should be multiplied by an optional integer and then added (in case the number of quotients of the mutual division is even) or subtracted (in case the number of quotients is odd) by the difference of the remainders. (Place the other quotients of mutual division successively one below the other in a column; below them the result just obtained and underneath it the optional integer). Any

1. अधिकप्रमाणहारं द्विन्वादूनाप्रमाणहारेण ।

शेषपरस्परमक्तं सतिगुणमग्रान्तरे क्षिप्तम् ॥

अथ उपरि गुणितमन्ययुक्ताग्रच्छेद भाजिते शेषम् ।

अधिकप्रच्छेदगुणं द्विच्छेदाप्रमधिकप्रयुतम् ।

number below (i.e. the penultimate) is multiplied by the one just above it and then added by that just below it. Divide the last number (obtained by doing so repeatedly) by the divisor corresponding to the smaller remainder; then multiply the residue by the divisor corresponding to the greater remainder and add the greater remainder. (The result will be) the number corresponding to the two divisors.

Āryabhaṭa's problem may be enunciated thus :

To find a number (N) which being divided by two given numbers (a, b) will leave two given remainders (R_1, R_2).

This gives :

$$N = ax + R_1 = by + R_2$$

(where R_1 is a greater remainder and R_2 lesser remainder, and a is the divisor corresponding to greater remainder and b the divisor corresponding to the lesser remainder.)

Denoting as before by c the difference between R_1 and R_2 , we get

$$(i) \quad by = ax + c, \text{ if } R_1 > R_2$$

$$(ii) \quad ax = by + c, \text{ if } R_2 > R_1$$

the equation being so written as to keep c always positive.

Hence the problem now reduces to making either

$$\frac{ax+c}{b} \text{ or } \frac{by+c}{a}$$

according as $R_1 > R_2$ or $R_2 > R_1$, a positive integer. So Āryabhaṭa says : Divide the divisor corresponding to the greater remainder etc."

Now we shall proceed with the details of the operation as proposed by Datta and Singh in his *History of Hindu Mathematics, Part II. Algebra* :

Suppose $R_1 > R_2$; then the equation to be solved will be

$$ax + c = by \quad \dots(i)$$

a, b being prime to each other.

Let

$$\begin{array}{r}
 b) \ a \ (q \\
 \underline{bq} \\
 r_1) \ b \ (q_1 \\
 \underline{r_1 q_1} \\
 r_2) \ r_1 \ (q_2 \\
 \underline{r_2 q_2} \\
 r_3 \\
 \dots \\
 r_{m-1}) \ r_{m-2} \ (q_{m-1} \\
 \underline{r_{m-1} q_{m-1}} \\
 r_m) \ r_{m-1} \ (q_m \\
 \underline{r_m q_m} \\
 r_m + 1
 \end{array}$$

Then we get (when $a < b$, we shall have $q=0$, $r_1=a$)

$$\begin{aligned}
 a &= bq + r_1 \\
 b &= r_1 q_1 + r_2 \\
 r_1 &= r_2 q_2 + r_3 \\
 r_2 &= r_3 q_3 + r_4 \\
 &\dots \dots \dots \\
 r_{m-2} &= r_{m-1} q_{m-1} + r_m \\
 r_{m-1} &= r_m q_m + r_m + 1
 \end{aligned}$$

Now, substituting the value of a in the given equation (1), we get

$$by = (bq + r_1)x + c$$

Therefore

$$y = qx + y_1$$

where

$$by_1 = r_1 x + c$$

In other words, since $a = bq + r_1$, on putting

$$y = qx + y_1 \tag{ii}$$

the given equation (i) reduces to

$$by_1 = r_1 x + c \tag{iii}$$

Again, since $b = r_1 q_1 + r_2$

putting similarly $x=q_1y_1+x_1$

the equation (iii) can be further reduced to

$$r_1x_1=r_2y_1-c \quad (\text{iv})$$

and so on.

Writing down the successive values and reduced equations in columns, we have

(1) $y=qx+y_1$	(I.1) $by_1=r_1x+c$
(2) $x=qy_1+x_1$	(I.2) $r_1x_1=r_2y_1-c$
(3) $y_1=q_2x_1+y_2$	(I.3) $r_2y_2=r_3x_1+c$
(4) $x_1=q_3y_2+x_2$	(I.4) $r_3x_2=r_4y_2-c$
(5) $y_2=q_4x_2+y_3$	(I.5) $r_4y_3=r_5x_2+c$
(6) $x_2=q_5y_3+x_3$	(I.6) $r_5x_3=r_6y_3-c$
.....
(2n-1) $y_{n-1}=q_{2n-2}x_{n-1}+y_n$	(I. 2n-1) $r_{2n-2}y_n=r_{2n-1}x_{n-1}+c$
(2n) $x_{n-1}=q_{2n-1}y_n+x_n$	(I. 2n) $r_{2n-1}x_n=r_{2n}y_n-c$
(2n+1) $y_n=q_{2n}x_n+y_{n+1}$	(I. 2n+1) $r_{2n}y_{n+1}=r_{2n+1}x_n+c$

Now the mutual division can be continued either (i) to the finish or (ii) so as to get a certain number of quotients and then stopped. In either case the number of quotients found, neglecting the first one (q), as is usual with Āryabhaṭa, may be even or odd.

Case (i) First suppose that the mutual division is continued until the zero remainder is obtained. Since a , b are prime to each other, the last one remainder is unity.

Subcase (i.1). Let the number of quotients be even. We then have

$$r_{2n}=1, r_{2n-1}=0, q_{2n}=r_{2n-1}$$

The equations (I.2n) and (I.2n+1), therefore become

$$y_n=q_{2n}x_n+c$$

and

$$y_{n+1}=c$$

respectively. Giving an arbitrary integral value (t) to x_n we get an integral value of y_n . From that we can find the value of x_{n-1} by the equation (2n). Proceeding backwards step by step we ultimately find the values of x and y in positive integers. So that the equation (I) is solved.

Subcase (i. 2) : If the number of quotients be odd, we shall have

$$r_{2n-1}=1, r_{2n}=0, q_{2n-1}=r_{2n-2}.$$

The equations $(2n+1)$ and $(I. 2n+1)$ will then be absent and the equations $(I. 2n-1)$ and $(I. 2n)$ will be reduced respectively to

$$x_{2n-1} = r_{2n-1} y - c$$

and $x_n = -c$

Giving an arbitrary integral value (t') to y_n we get an integral value of x_{2n-1} . Then proceeding backwards as before we calculate the values of x and y .

Case (ii) : Next suppose that the mutual division is stopped after having obtained an even or odd number of quotients.

Subcase (ii.1) : If the number of quotients obtained be *even* the reduced form of the original equation is

$$r_2 y + 1 = r_{2n} + 1 x_n + c$$

$$\text{or } y_n + 1 = \frac{r_{2n} + 1 x_n + c}{r_2}$$

Giving a suitable integral value (t) to x_n as will make

$$y_n + 1 = \frac{r_{2n} + 1 t + c}{r_2} = \text{an integral number,}$$

we get an integral value for y_n by $(2n+1)$. The values of x and y can then be calculated by proceeding as before.

Subcase (ii.2) : If the number of quotients be *odd* the reduced form of the quotient is

$$r_{2n-1} x_n = r_{2n} y_n - c$$

$$\text{or } x_n = \frac{r_{2n} y_n - c}{r_{2n-1}}$$

Putting $y_n = t'$, where t' is an integer, such that

$$x_n = \frac{r_{2n} t' - c}{r_{2n-1}} = \text{a whole number,}$$

we get an integral value of x_{2n-1} by $(2n)$. Whence can be calculated the values of x and y in integers.

If $x = \alpha$ and $y = \beta$ be the least integral solution of $ax + c = by$, we shall have

$$a\alpha + c = b\beta$$

Therefore $a(bm + \alpha) + c = b(am + \beta)$,

m being any integer. Therefore, in general,

$$x = bm + \alpha$$

But we have calculated before that

$$x = q_1 y_1 + x_1 ;$$

$$\therefore q_1 y_1 + x_1 = bm + \alpha$$

Thus it is found that the minimum value α of x is equal to the remainder left on dividing its calculated value by b . whence we can calculate the minimum value of $N (=a\alpha + R_1)$. This will explain the *rationale* of the operations described in the latter portion of the rule of Āryabhaṭa I.

Bhāskara I and Kuṭṭaka Operation

In Chapter I of the *Mahābhāskarīya*, Bhāskara I has described the preliminary operation to be performed on the divisor and dividend of a pulveriser. We shall quote it from the edition of K.S. Shukla :

The divisor (which is "the number of civil days in a *yuga*") and the dividend (which is "the revolution number of the desired planet") become prime to each other on being divided by the (last non-zero) residue of the mutual division of the number of civil days in a *yuga* and the revolution number of the desired planet. The operations of the pulveriser should be performed on them (i. e. on the abraded divisor and abraded dividend). So has been said.¹

An indeterminate equation of the first degree of the type

$$\frac{ax - c}{a} = y$$

(with x and y unknown) is known in Hindu mathematics by the name of "pulveriser"—*kuṭṭakāra*). In this equation, a is called the "dividend" (*bhājya*), b the "divisor" (*bhāgahāra*), c the interpolator (*kṣepa*), x the "multiplier" (*guṇakāra*), and y the "quotient" (*labdha*).

In the pulveriser contemplated in the above stanza :

a = revolution number of a planet.

b = civil days in a *yuga*,

c = residue of the revolutions of the planet (*Śeṣa*)

1. भूदिनेष्टगणान्योन्य भक्तरोपेय भाजि इ
हारभाज्यौ दृढौ स्यतां कुट्टाकारं तयोर्विदुः ।

$x = \text{ahargana}$,

and $y = \text{complete revolutions performed by the planet.}$

The text says that as a preliminary operation to the solution of this pulveriser, a and b , i.e., civil days in *yuga* and revolution-number of the planet, should be made prime to each other by dividing them out by their greatest common factor. That is to say, in solving a pulveriser, one should always make use of abraded divisor and abraded dividend.

The interpolator, i.e., the residue, should also be divided out by the same factor. (This instruction is not given in the text, but it is implied that the residue should be computed for the abraded dividend and abraded divisor).

Set down the dividend above and the divisor (*hāra*) below that. Divide them mutually and write down the quotients (*labdha*) of division one below the other (in the form of a chain). (When an even number of quotients is obtained) think out by what number the (last) remainder be multiplied so that the product being diminished by the (given) residue be exactly divisible (by the divisor corresponding to that remainder). Put down the chosen number called *mati* below the chain and then the new quotient underneath it. Then by the chosen number multiply the number which stands just above it, and to the product add the quotient (written below the chosen number). (Replace the upper number by the resulting sum and cancel the number below). Proceed afterwards also in the same way (until only two numbers remain). Divide the upper number (called the "multiplier") by the divisor by the usual process and the lower one (called the "quotient") by the dividend: the remainders (thus obtained) will respectively be the *ahargana* and the revolutions etc. or what one wants to know.¹

We shall illustrate the operation by taking a problem from the *Laghu-Bhāskarīya* (VIII. 17):

The sum, the difference, and the product increased by one, of the residues of the revolution of Saturn and Mars—each is a perfect square. Taking the equations

furnished by the above and applying the method of such quadratics, obtain the (simplest) solution by the substitution of 2, 3 etc. successively in the general solution). Then calculate the *ahragana* and the revolutions performed by Saturn and Mars in that time together with the number of solar years elapsed.¹

Let x and y denote the residues of the revolution of Mars and Saturn respectively. Then we have to find out two numbers x and y such that each of the expressions $x+y$, $x-y$ and $xy+1$ may be a perfect square.

Let $x+y=4P^2$ and $x-y=4Q^2$, so that

$$x=2P^2+2Q^2$$

$$y=2P^2-2Q^2$$

and therefore $xy+1=(2P^2-1)^2+4(P^2-Q^4)$

Hence the condition that $xy+1$ be a perfect square is that $P^2=Q^4$. Substituting these values, we have

$$x=2(Q^4+Q^2)$$

$$y=2(Q^4-Q^2)$$

where Q may possess any of the values 2, 3, 4.....but not 1. (We neglect the case when x or y is zero).

1. भाज्यं न्यसेदुपरि हारमधश्च तस्य ।
खण्डयात्परस्परमधो विनिधाय लब्धम् ।
केनाऽऽहतोऽयमपनीय यथाऽस्य शेष ।
भागं ददाति परिशुद्धमिति प्रचिन्त्यम् ॥

आप्तां मतिं तां विनिधाय वल्ल्यां
नित्यं ह्यधोऽधः क्रमशश्च लब्धम् ।
मत्या हतं स्यादुपरिस्थितं य
ल्लब्धेन युक्तं पातश्च तद्वत् ॥

हारेणभाज्यो विधिनोपरिस्थो
भाज्येन नित्यं तदधः स्थितश्च ।
अर्थांगखोऽस्मिन् भगणद्वयश्चै
तद्वा भवेद्यस्य समीहितं यत् ॥

—MBh, I, 42-44

2. शेषौ मण्डलजौ यमक्षितिजयोः संयुक्तविश्लेषिता
वन्योन्महत्तन्निग्रहौ च पददौ रूपेण संयोजितौ ।
एवं साधु विचिन्त्य वर्गविधिना द्वित्रिकमाद्वत्सरैः ।
संगण्या च गुणार्कजक्षिति सुताः कालेन कालोद्भवाः ॥

—LBh. VI. 11. 17

Putting $Q=2$, we get $x=40$ and $y=24$, which is the least solution.

Assuming now that the residues of the revolution (*maṇḍa-laja-seṣa*) of Saturn and Mars are 24 and 40 respectively, we have to obtain the *ahargana* (which means the number of mean civil days elapsed since the beginning of Kaliyuga, or, in fact, any epoch).

The revolution-number of Saturn is 146564 and the number of civil days in a *yuga* is 1,577,917,500. In the present problem, these are respectively the dividend and the divisor. Their H.C.F. is 4, so that dividing them out by 4 we get 36641 and 394,479,375 as the abraded dividend and abraded divisor respectively. We have, therefore, to solve the pulveriser

$$\frac{36641x - 24}{394479375} = y$$

where x and y denote the *ahargana* and the revolutions respectively made by Saturn.

Mutually dividing 36641 and 394479375, we get

$$\begin{array}{r}
 36641 \overline{) 394479375} \quad (10766 \\
 \underline{394477006} \\
 2369 \overline{) 36641} \quad (15 \\
 \underline{35535} \\
 1106 \overline{) 2369} \quad (2 \\
 \underline{2212} \\
 157 \overline{) 1106} \quad (7 \\
 \underline{1099} \\
 7 \overline{) 157} \quad (22 \\
 \underline{154} \\
 3 \overline{) 7} \quad (2 \\
 \underline{6} \\
 1 \times 27 - 24 = 3 \overline{) 3} \quad (1 \\
 \underline{3} \\
 0
 \end{array}$$

We have chosen here the number 27 as the optional number (*mati*). In fact, *mati* may be chosen at any stage after an even number of quotients are obtained.

Writing down the quotients one below the other as prescribed in the rule, we get the chain

10766
15
2
7
22
2
(*mati*) 27
1

Reducing the chain, we successively get

10766	10766	10766	10766	10766	10766	3108044439
						(multiplier)
15	15	15	15	15	288689	288689
						(quotient)
2	2	2	2	18665	18665	
7	7	7	8714	8714		
22	22	1237	1237			
2	55	55				
(<i>mati</i>)						
27	27					
1						

(it would be seen in this reduction of chain that *mati* or 27×2 plus 1 is 55; 55×22 plus 27 is 1237; 1237×7 plus 55 is 8714; 8714×2 plus 1237 is 18665; 18665×15 plus 8714 is 288689; and finally 288689×10766 plus 18665 is 3108044439 which is the multiplier).

Dividing 3108044439 by 394479375, and 288689 by 36641, we obtain 346688814 and 32202 respectively as remainders. (This division is performed only when the multiplier and quotient are greater than the divisor and dividend respectively). These are the minimum values of x and y satisfying the above equation.

Therefore, the required *ahargana* = 346688814, and the revolutions performed by Saturn = 32202.

To obtain the *ahargana* and the revolutions of Mars, one has to solve the equation :

$$\frac{191402z - 40}{131493125} = w$$

where z and w denote the *ahargana* and the revolutions performed by Mars respectively.

The general solution of this equation is

$$z = 131493125s + 118076020$$

$$w = 191402s + 171872$$

where $s = 0, 1, 2, 3, \dots$. When $s = 0$, we have the least solution.

Brahmagupta's Rules Concerning Indeterminate Analysis of the First Degree

For the solution of Āryabhaṭa's problem, Brahmagupta gives the following rule :

What remains when the divisor corresponding to the greater remainder is divided by the divisor corresponding to the smaller remainder—that (and the latter divisor) are mutually divided and the quotients are severally set down one below the other. The last residue (of the reciprocal division after an even number of quotients has been obtained) is multiplied by such an optional integer that the product being added with the difference of the (given) remainders will be exactly divisible (by the divisor corresponding to that residue). That optional multiplier and then the (new) quotient just obtained should be set down (underneath the listed quotients). Now, proceeding from the lower-most number (in the column), the penultimate is multiplied by the number just above it and then added by the number just below it. The final value thus obtained (by repeating the above process) is divided by the divisor corresponding to the smaller remainder. The residue being multiplied by the divisor corresponding to the greater remainder and added to the greater remainder will be the number in view.¹

1. अधिकप्रमाणहाराद्विनाशच्छेद भाजिताच्छेषम् ।
यत् तत् परस्परहृतं लब्धमयोऽधः पृथक् स्थाप्यम् ॥
शेषं तदेष्टुणितं यथाऽऽयोरन्तरेण संयुक्तम् ।
शुच्यति गुणकः स्थाप्यो लब्धं चान्त्यादुपान्त्यगणः ॥
स्वोर्ध्वोऽन्त्य युतोऽग्रान्तो द्विनाशच्छेदभाजितः शेषम् ।
अधिकप्रच्छेदहतं अधिकप्रयुक्तं मकल्यम् ॥

Brahmagupta further observes :

Such is the process when the quotients (of mutual division) are even in number. But if they be odd, what has been stated before as negative should be made as positive, or as positive should be made negative.¹

Regarding the direction for dividing the divisor corresponding to the greater number by the divisor corresponding to the smaller remainder, Pṛthudaka Svāmī (860 A.D.) observes that it is not absolute, rather optional; so that the process may be conducted in the same way by starting with the division of the divisor corresponding to the smaller remainder by the divisor corresponding to the greater remainder. But in this case of inversion of the process, he continues, the difference of the remainders, must be negative.

That is to say, the equation

$$by = ax + c$$

can be solved by transforming it first to the form

$$ax = by - c$$

so that we shall have to start with the division of b by a .

For the details of the "Theory of the pulveriser" as applied to the problems in Astronomy, the reader is referred to the writings of Bhaṭṭa Govind, translated by K.S. Shukla, and given as an Appendix to the edition of the *Laghu-Bhāskariya*. For the *rationale* of the rules in relation to *kuṭṭaka* or the pulveriser operation, one may also refer to the chapters by Datta and Singh in the *History of Hindu Mathematics: Algebra*.

$$\text{Solution of } by = ax \pm 1.$$

This simple indeterminate equation has a special use in astronomical calculations and therefore, Indian algebraists have paid special attention to it. In fact, this equation is solved exactly in the same way as the equation $by = ax \pm c$; it is a parti-

1. एवं समेषु विषमेष्वृणं धनं धनमृणं यदुक्तं तत् ।

ऋणधनयोर्व्यस्तत्वं गुण्य प्रक्षेपयोः कार्यम् ॥

—BrSpSi. XVIII. 13.

cular case only of the more general latter equation. Of course, there is a little justification also for treating it separately, since both the types of equations represent two different physical conditions of the astronomical problems. In the case of $by=ax\pm c$, the conditions are such that the value of either y or x , more particularly of the latter, has to be found and the rules for solution formulated with that objective. But in the case of the equation $by=ax\pm 1$, the physical conditions require the values of both y and x .

The equation $by=ax\pm 1$ is usually known by the name *sthira-kuttaka*, literally meaning the 'constant pulveriser' Prthūdaka Svāmī also names it as *dyḍha-kuttaka* meaning firm-pulveriser. Later on this term *dyḍha* was confined to another sense, equivalent to *nicched* (having no divisor) or *nirapavarta* (irreducible). The origin of the name *sthira-kuttaka* or constant pulveriser has been explained by Prthūdaka Svāmī as being due to the fact that the interpolator (± 1) is here invariable.

For the solution of this equation, we shall quote Bhāskara I's rule and the rule by Brahmagupta. Bhāskara I writes in this connection as follows :

The method of the pulveriser is applied also after subtracting unity. The multiplier and quotient are respectively the numbers above and underneath. Multiplying those quantities by the desired number divide by the reduced divisor and dividend; the residues are in this case known to be the (elapsed) days and (residues of) revolutions respectively¹.

The pulveriser

$$\frac{ax-c}{b}=y \quad \dots (1)$$

may be written as

$$\frac{aX-1}{b}=Y \quad \dots (2)$$

where $x=cX$ and $y=cY$. If $X=\alpha$, $Y=\beta$ is a solution of (2), then $x=c\alpha$, $y=c\beta$ will be a solution of (i). Hence the above rule.

1. रूपमेकमपास्यापि कुदाकारः प्रसाध्यते ।
गुणकातोऽयं लब्धं च राशी स्यातामुपर्येषः ॥

Brahmagupta's Rule in this connection is as follows :

Solution of $by = ax - 1$:

Divide them (i.e., the abraded coefficient of the multiplier and the divisor) mutually and set down the quotients one below the other. The last residue (or the reciprocal division after an even number of quotients has been obtained) is multiplied by an optional integer such that the product being diminished by unity will be exactly divisible (by the divisor corresponding to that residue). The (optional) multiplier and then this quotient should be set down (underneath the listed quotients). Now proceeding from the lower most term to the uppermost, by the penultimate multiply the term just above it and then add the lowermost number. (The uppermost number thus calculated being divided by the reduced divisor, the residue (is the quantity required. This is the method of the constant pulveriser¹.

Solution of

$$by + ax = \pm c$$

Indian algebraists usually transformed this equation as $by = -ax + c$, so that it appeared as a particular case of $by = ax + c$, in which a was negative. Brahmagupta has been the first person to solve this equation, but the rule given by him is obscure :

The reversal of the negative and positive should be made of the multiplier and interpolator.²

Prthudaka Svāmī has tried to explain it, but he too is not very clear. He says :

1. हृतयोः परस्परं यच्छेषं गुणकार भागद्वययोः ।
तेन हतौ निश्छेदौ तावेव परस्परं हृतयोः ॥
लब्धमधोऽधः स्थायं तथेष्ट गुणकारसङ्गुणं शेषम् ।
शुद्ध्यति यथैकहीनं गुणकः स्थायः फलं चास्त्यात् ॥
अग्रान्तमुपान्त्येन स्वोर्ध्वं गुणितोऽन्त्य संयुतो भक्तम् ।
निःशेषभागद्वारेणैवं स्थिरकुट्टकः शेषम् ॥

—BrSpSi. XVIII. 9-11

2. एवं समेषु विषमेष्वर्णं धनं धनसृणं यदुक्तं तत् ।
अणधनयोर्व्यस्तत्वं गुण्यप्रक्षेपयोः कार्यम् ॥

BrSpSi XVIII. 13

If the multiplier be negative, it must be made positive; and the additive must be made negative : and then the method of the pulveriser should be employed.

Prthūdaka Svāmī, however, does not indicate how to derive the solution of the equation .

$$by = -ax + c \quad \dots(1)$$

from that of the equation

$$by = ax - c \quad \dots(2)$$

The method, however, seems to have been this :

Let $x=a$, $y=\beta$ be the minimum solution of (2). Then we get

$$b\beta = a^2 - c$$

$$\text{or} \quad b(a-\beta) = -a(a-b) + c$$

Hence $x=a-b$, $y=a-\beta$ is the minimum solution of (1). This rule is very clearly indicated by Bhāskara II and others.

We shall give two examples from Bhāskara II (*Bījaganita*) to illustrate the rule :

Example I.

$$13y = -60x + 3$$

By the method described before, we find that the minimum solution of

$$13y = 60x + 3$$

is $x=11$, $y=51$. Subtracting these values from their respective abraders, namely 13 and 60, we get 2 and 90. Then by the maxim : "In the case of the dividend and divisor being of different signs, the results from the operation of division should be known to be so", making the quotient negative we get the solution of

$$13y = -60x + 3$$

as $x=2$, $y=-9$. Subtracting these values again from their respective abraders (13, 60), we get the solution of

$$13y = -60x - 3$$

as $x=11$, $y=-51$.

Example II.

$$11y = 18x + 10$$

Proceeding as before, we find the minimum solution of

$$11y=18x+10$$

to be $x=8$, $y=14$. These will also be the values of x and y in the case of the negative divisor but the quotient for the reasons stated before should be made negative. So the solution of

$$-11y=18x+10$$

is $x=8$, $y=-14$. Subtracting these (i.e., their numerical values) from their respective abraders, we get the solution of

$$-11y=18x-10$$

as $x=3$, $y=-4$,

“When the divisor is positive or negative the numerical values of the quotient and multiplier remain the same : when either the divisor or the dividend is negative, the quotient must always be known to be negative”¹.

One Linear Equation in More Than Two Unknowns

Whenever a linear equation involves more than two unknown's the Indian algebraists used to assume arbitrary values for all the unknowns except two and then to apply the method of *kut-taka* or “pulveriser”. In this connection, Brahmagupta says :

The method of the pulveriser (should be employed if there be present many unknowns (in any equation)²,

1. Bhāskara II gives the following rule :

“Those (the multiplier and quotient) obtained for a positive dividend being treated in the same manner give the results corresponding to a negative dividend.”

The treatment alluded to in this rule is that of subtraction from the respective abraders. He has further elaborated it thus :

The multiplier and quotient should be determined by taking the dividend, divisor and interpolator as positive. They will be the quantities for the additive interpolator. Subtracting them from their respective abraders, the quantities for a negative interpolator are found. If the dividend or divisor, be negative, the quotient should be stated as negative, the quotient should be stated as negative.

—*Bījaganita*

1. आद्याद्वर्णादन्यान् वर्णान् प्रोह्याद्यमानमाद्यहृतम् ।
सदृशच्छेदावसकृद् द्वौ व्यस्तौ कुर्वो बहुषु ॥

—*BrSpSi. XVIII. 51*

We shall take up one of the problems posed by Brahmagupta concerning astronomy and leading to the equation :¹

$$197x - 1644y - z = 6302.$$

Hence

$$x = \frac{1644y + z + 6302}{197}$$

The commentator assumes $z=131$. Then

$$x = \frac{1644y + 6433}{197};$$

hence by the usual method of the pulveriser

$$x=41; y=1.$$

General Problem of Remainders

A certain type of simultaneous indeterminate equations of the first degree arise out of the general problem of remainders which may thus be stated : To find a number N which being severally divided by $a_1, a_2, a_3, \dots, a_n$, leaves as remainders $r_1, r_2, r_3, \dots, r_n$ respectively.

While dealing with such a case, we shall have the following series of equations :

$$N = a_1x_1 + r_1 = a_2x_2 + r_2 = a_3x_3 + r_3 = \dots = a_nx_n + r.$$

We have reasons to believe that the method of solution of these equations was known to Āryabhaṭa I. In the translation of the verse in the *Āryabhaṭīya*, II. 32-33 (the translation of which we have already given), the term *dvicchedāgram* should be translated as "the result will be the remainder corresponding to the product of the two divisors", instead of "the result will be the number corresponding to the two divisors." (the last line of the translation). This explanation is in fact given by Bhāskara I, the direct disciple and earliest commentator of Āryabhaṭa I. Such a rule is clearly stated by Brahmagupta².

1. अंशकरोषेय युतात् लिप्ताशेषात्तदन्तरादथवा ।

मानोर्द्दिने कुण्ठं यः कथयति कुट्टकः सः ॥

—*BrSpSi*. XVIII. 55

2. स्वोर्ध्वोऽन्त्ययुतोऽग्रान्तो हीनम्यच्छेदमाजितः शेषम् ।

अधिकम्यच्छेदह्यतमधिकम्ययुतं भवत्यग्रम् ॥

—*BrSpSi*. XVIII. 5

The rationale of this method is not difficult. I shall quote it from the book of Datta and Singh: Starting with the consideration of the first two divisors, we have

$$N = a_1x_1 + r_1 = a_2x_2 + r_2.$$

By the method described before, we can find the minimum value α of x_1 satisfying this equation. Then the minimum value of N will be $a_1\alpha + r_1$. Hence the general value of N will be given by

$$\begin{aligned} N &= a_1 (a_2t + \alpha) + r_1 \\ &= a_1a_2t + a_1\alpha + r_1 \end{aligned}$$

where t is an integer. Thus $a_1\alpha + r_1$ is the remainder left on dividing N by a_1a_2 as stated by Āryabhaṭa I and Brahmagupta. Now taking into consideration the third condition, we have

$$N = a_1a_2t + a_1\alpha + r_1 = a_3x_3 + r_3$$

which can be solved in the same way as before. Proceeding in this way successively, we shall ultimately arrive at a value of N satisfying all the conditions ;

Prthūdaka Svāmī remarks :

Wherever the reduction of two divisors by a common measure is possible, there 'the product of the divisors' should be understood as equivalent to the product of the divisor corresponding to the greater remainder and quotient of the divisor corresponding to the smaller remainder as reduced (i.e. divided) by the common measure.¹ When one divisor is exactly divisible by the other, then the greater remainder is the (required) remainder and the divisor corresponding to the greater remainder is taken as 'the product of the divisors'. (The truth of) this may be investigated by an intelligent mathematician by taking several symbols.

As an illustration we shall take up a problem quoted by Bhāskara II in his *Bijaganita*, and which in its solution follows the method of Āryabhaṭa I. Prthūdaka Svāmī while commenting on several verses from Brahmagupta (*BrSpSi*. XVIII. 3-6)

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1. i.e., if p be the L.C.M. of a_1 and a_2 , the general value of N satisfying the above two conditions will be

$$N = pt + a_1\alpha + r_1,$$

instead of $N = a_1a_2t + a_1\alpha + r_1.$

observes that such problems were very popular amongst the ancient Indian mathematicians.

Problem : To find a number N which leaves remainders 5, 4, 3, 2 when divided by 6, 5, 4, 3 respectively.

That is to solve the equations :

$$N=6x+5=5y+4=4z+3=3w+2.$$

We have since $N=6x+5=5y+4$,

$$x = \frac{5y-1}{6}$$

But x must be integral, so $y=6t+5$, $x=5t+4$

$$\text{Hence } N=30t+29$$

Again $N=30t+29=4z+3$

$$\text{Therefore, } t = \frac{2z-13}{15}$$

Since t must be integral, we must have $z=15s+14$;
hence $t=2s+1$. Therefore

$$N=60s+59.$$

The last condition is identically satisfied. The method given here is the one followed by *Prthudaka Svāmī*.

Thus when $N=60s+59=6x+5$

$$x = \frac{60s+54}{6} = 10s+9 \quad \dots(1)$$

Again, when $N=60s+59=5y+4$,

$$y = \frac{60s+55}{5} = 12s+11$$

Again when $N=60s+59=4z+3$

$$z = \frac{60s+56}{4} = 15s+14$$

Lastly, when $N=60s+59=3w+2$,

$$w = \frac{60s+57}{3} = 20s+19.$$

Varga Prakṛti or Kṛti Prakṛti or Square-Nature

The word *varga-prakṛti* (literally meaning 'square-nature') has been given by Indian algebraists to the indeterminate quadratic equation

$$Nx^2 \pm c = y^2$$

Here in this equation the absolute number c should be *rūpa* (or unity), which means the equation

$$Nx^2 \pm 1 = y^2$$

or it may be any absolute number. The most fundamental equation of this class has been regarded as

$$Nx^2 + 1 = y^2$$

where N is a non-square integer.

This branch of mathematics has originated from the number which is the *prakṛti* of the square of *yāvat*, etc. (the unknown x etc.), and therefore, it is called *varga-prakṛti*. The quantity N of the above equation is known as *Prakṛti*. Brahmagupta uses the term *GUṆAKA* (*multiplier*) for the same purpose¹.

This term *guṇaka* together with its variation *guṇa* appears occasionally also in the writings of later authors. For example, Śrīpati (*Siddhānta-śekhara*. XIV. 32) employs the term *guṇaka* where as Bhāskara II and Nārāyaṇa use the term *guṇa* in their *Bījagaṇitas*.

In this connection, we would now like to quote from Pṛthūdaka Svāmī (863 A.D.) from his commentary on the *Brāhmasphuṭasiddhānta* :

Here are stated for ordinary use the terms which are well known to people. The number whose square, multiplied by an optional multiplier and then increased or decreased by another optional number, becomes capable of yielding a square-root, is designated by the term the "lesser root" *kaniṣṭha pada* or the "first root" *ādya-mūla*). The root which results, after those operations have been performed is called by the name the "greater root" (*jyeṣṭha pada*) or the "second root" (*anya-mūla*). If there be a number multiplying both these roots, it is called the "augmenter" (*udvartaka*); and on the contrary, if there be a number dividing the roots, it is called the "abridger" (*apavartaka*).

Thus in the equation

$$Nx^2 \pm c = y^2,$$

1. मूलं द्विवेधं वर्गाद् गुणकं गुणादिव्युत्तं विहीतान्च ।

आववधो गुणकगुणः सहान्यधातेन कृतमन्त्यम् ॥

2. *BrSpSi*. XVIII. 64 (Com.)

x is known as the lesser root, y is the greater root, N is the multiplier (*gunaka*) and c is interpolator or *kṣepaka*. Bhāskara II has used the word "*hrasvamūla*" for *kaniṣṭha pada* or *ādyamūla* literally meaning "lesser root". The earlier terms, the "first root" (*ādyamūla*) for the value of x and the "second root" or the "last root" *antya-mūla* for the value of y are quite free from ambiguity. Their use is found in the algebra of Brahmagupta. The later terms appears in the works of his commentator Pṛthūdaka Svāmī.

Brahmagupta uses the term *kṣepa*, *prakṣepa* or *prakṣepaka* in the sense of "interpolator." Again, when negative, the interpolator is sometimes distinguished as the "subtractive" or *sodhaka* and the positive interpolator is then called "the additive."

Lemmas of Brahmagupta

Prior to our giving the general solution of the Square-nature or *Varga-Prakṛti*, it would be better to give two Lemmas established by Brahmagupta. We have the following in the *Brahmasphuṭasiddhānta* :

Of the square of the optional number multiplied by the *gunaka* and increased or decreased by an other optional number, *iṣṭa*, (extract) the square root. (Proceed) twice. The product of the first roots multiplied by the *gunaka* together with the product of the second roots will give a (fresh) second root; the sum of their cross-products will be a (fresh) first root. The (corresponding) interpolator will be equal to the product of the (previous) interpolators.¹

There is a little difficulty in ascertaining the real sense of the rule given in these lines since the word *dvidha* (twice) has two implications. Firstly, it may mean that the earlier operations of finding roots are made on two optional numbers with two optional interpolators, and with the results thus obtained the subse-

1. मूलं द्विवेष्टकानां गुणकं गुणादिष्टयुतं विहीनाच्च ।

आद्यवधो गुणकगुणः सहान्त्यवातेन कृतमन्त्यम् ॥

वज्रवधैक्यं प्रथमं प्रक्षेपः क्षेपवध तुल्यः ।

प्रक्षेपशोधकद्वये मूले प्रक्षेपके रूपे ॥

quent operations of their composition are performed. Secondly, it may also mean that the earlier operations are made with one optionally chosen number and one interpolator, and the subsequent ones are carried out after the repeated statement of those roots for the second time. It is also implied that in the composition of the quadratic roots, their products may be added together or subtracted from each other.

In other words, if $x=\alpha$, $y=\beta$ be a solution of the equation :

$$Nx^2+k=y^2,$$

and $x=\alpha'$, $y=\beta'$ be a solution of

$$Nx^2+k'=y'^2,$$

then according to the above

$$x=\alpha\beta'\pm\alpha'\beta, y=\beta\beta'\pm N\alpha\alpha'$$

is a solution of the equation

$$Nx^2+kk'=y'^2.$$

In other words, if

$$N\alpha^2+k=3^2$$

$$N\alpha'^2+k'=3'^2$$

then

$$N(\alpha\beta'\pm\alpha'\beta)^2+kk'=(\beta\beta'\pm N\alpha\alpha')^2 \quad (I)$$

In particular, taking $\alpha=\alpha'$, $\beta=\beta'$ and $k=k'$, Brahmagupta finds from a solution $x=\alpha$, $y=\beta$ of the equation

$$Nx^2+k^2=y^2$$

a solution $x=2\alpha\beta$, $y=\beta^2+N\alpha^2$ of the equation

$$Nx^2+k=y^2$$

That is, if

$$N\alpha^2+k=\beta^2$$

then

$$N(2\alpha\beta)^2+k^2=(\beta^2+N\alpha^2)^2 \quad (II)$$

This result will be hereafter called *Brahmagupta's Corollary*.

Thus *Brahmagupta's First Lemma* says that if two solutions of the equation (of the Square-nature) $Nx^2+1=y^2$ are known, then any number of other solutions can be found. For example if two solutions of the Square-nature are (a, b) and also (a', b') , then two other solutions will be :

$$x=ab'+a'b, y=bb'\pm Naa'.$$

We can compose this solution with the previous ones, and get another solution, and thus proceed on to innumerable solutions. From *Brahmagupta's Corollary to First Lemma* we get another set of solutions. If (a, b) be solution of the Square-nature, then another solution of it is

$$x=2ab, \text{ and } y=b^2+Na^2$$

Thus even if we have only one solution, we can get the other solution also (since N is known), and thus we can get any number of solutions one after the other by this Principle of Composition.

Brahmagupta's Lemmas have been described by Bhāskara II (1150 A.D.) in the following words :

Set down successively the lesser root (*hrasva*), greater root (*jyeṣṭha*) and interpolator (*kṣepaka*); and below them should be set down in order the same or another (set of similar quantities). From them by the Principle of Composition (*Bhāvanā*) can be obtained numerous roots. Therefore the Principle of Composition will be explained here. (Find) the two cross-products (*vajrābhyāsa*) of the two lesser and the two greater roots; their sum is a lesser root. Add the product of the two lesser roots multiplied by the *prakṛti* to the product of the two greater roots, the sum will be a greater root. In that (equation) the interpolator will be the product of the two previous interpolators. Again the difference of the two cross-products is a lesser root. Subtract the product of the two lesser roots multiplied by the *prakṛti* from the product of the two greater roots; (the difference) will be greater root. Here also the interpolator is the product of the two (previous) interpolators.¹

1. ह्रस्वज्येष्ठ क्षेपकान् न्यस्य तेषां तानन्यान् वाऽथो निवेश्य क्रमेण ।
साध्यान्त्येभ्यो भावनामिदं ह्रस्वमूलान्येषां भावना प्रोच्यतेऽतः ॥
वज्रान्यासौ ज्येष्ठलब्धोस्तदैक्यं ह्रस्वं लब्धोराहतिश्च प्रकृत्या ।
क्षुरणा ज्येष्ठान्यास युग्मं ज्येष्ठमूलं तत्रान्यासः क्षेपयोः क्षेपकः स्यात् ॥
ह्रस्वं वज्रान्यासयोरन्तरं वा लब्धोर्धातो यः प्रकृत्या विनिज्जः ।
धातो यस्य ज्येष्ठयोस्तद्वियोगो ज्येष्ठं क्षेपोत्रापि च क्षेपधातः ॥

Bhāskara II, *Bijaganita, VargaPrakṛti.2-4*

Principle of Composition

The above results have been technically known amongst Indian algebraists as *Bhāvanā* (demonstrated or proved, hence theorem or lemma). The word *bhāvanā* also means "composition or combination" in algebra. *Bhāvanā* may be of two types : *Samāsa Bhāvanā* (or addition Lemma, or additive composition) and *Antara Bhāvanā* (or subtraction Lemma or subtractive composition). Whenever, again, the *bhāvanā* is made with two equal sets of roots and interpolators, it is technically named as *Tulya Bhāvanā* (or composition of equals), and when with two unequal sets of values then it is known as *Atulya Bhāvanā* (or composition of unequals).

Proof of Brahmagupta's Lemmas

It is significant to be indicated that Brahmagupta's Lemmas were rediscovered by Euler in 1764 and by Lagrange in 1768, and a considerable importance was attached to them. Kṛṣṇa, (1580 A.D.) the commentator on the *Bījaganita* of Bhāskara II gives the following proof of Brahmagupta's Lemmas :

Let (α, β) and (α', β') be the two solutions of the equation $nx^2 + k = y^2$.

we have

$$N\alpha^2 + k = \beta^2$$

$$N\alpha'^2 + k = \beta'^2$$

Multiplying the first equation by β'^2 , we get

$$N\alpha^2\beta'^2 + k\beta'^2 = \beta^2\beta'^2$$

Now, substituting the value of factor β'^2 of the interpolator from the second equation, we get

$$N\alpha^2\beta'^2 + k(N\alpha'^2 + k') = \beta^2\beta'^2$$

$$\text{or } N(\alpha^2\beta'^2 + Nk\alpha'^2 + kk') = \beta^2\beta'^2$$

Again, substituting the value of k from the first equation in the second term of the left-hand side expression, we have

$$N\alpha^2\beta'^2 + N\alpha'^2(\beta^2 - N\alpha^2) + kk' = \beta^2\beta'^2$$

$$\text{or } N(\alpha^2\beta'^2 + \alpha'^2\beta^2) + kk' = \beta^2\beta'^2 + N^2\alpha^2\alpha'^2$$

Adding $\pm 2N\alpha\alpha'\beta'$ to both sides, we get

$$N(\alpha\beta' \pm \alpha'\beta)^2 + kk' = (\beta\beta' \pm N\alpha\alpha')^2$$

Brahmagupta's Corollary also follows at once from the above by putting $\alpha'=\alpha$, $\beta'=\beta$ and $k'=k$.

$$N(2\alpha\beta)^2+k^2=(\beta^2\pm N\alpha^2)^2$$

Thus the roots are $x=2\alpha\beta$ and $y=\beta^2\pm N\alpha^2$ which is the Corollary.

It would be seen that modern historians of mathematics are incorrect when they say that Fermat (1657) was the first to state that the equation $Nx^2+1=y^2$, where N is a non-square integer has an unlimited number of solutions in integers. For this assertion, history takes us to the early Seventh Century A.D. when Brahmagupta wrote his classical treatise the *Brāhmasphuṭasiddhānta*, and gave the well known two Lemmas and the Corollary to the first Lemma.

Second Lemma of Brahmagupta

In the *Brāhmasphuṭa siddhānta*, we find another important Lemma by Brahmagupta stated as follows :

On dividing the two roots (of a square- Nature) by the square-root of its additive or subtractive, the roots for interpolator unity (will be found).¹

This Lemma when expressed in the modern language of algebra would mean that if $x=\alpha$, $y=\beta$ be a solution of the equation.

$$Nx^2+k^2=y^2$$

then $x=\alpha/k$, $y=\beta/k$ is a solution of the equation

$$Nx^2+1=y^2.$$

This rule, at another place, has been re-enunciated as follows :

If the interpolator is that divided by a square then the roots will be those multiplied by its square-root.²

1. प्रद्वे परोधक इवे मूले प्रद्वे पके रूपे ।

—BrSpSi. XVIII. 65

2. कर्माच्छिन्ने द्वे पे तत्पदगुणिते तदा मूले ।

—BrSpSi. XVIII. 70

This rule may be expressed in terms of symbols as follows.

Suppose the *Varga-prakṛti* (Square-nature) to be

$$Nx^2 \pm p^2 d = y^2,$$

so that its interpolator (*kṣepa*) $p^2 d$ is exactly divisible by the square p^2 . Then, putting therein $u = x/p$, $v = y/p$, we derive the equation

$$Nu^2 \pm d = v^2$$

whose interpolator is equal to that of the original Square-nature divided by p^2 . It is clear that the roots of the original equation are p times those of the derived equation.

Rational Solution

Indian algebraists have usually suggested the following method to obtain a first solution of $Nx^2 + 1 = y^2$:

Take an arbitrary small rational number, α , such that its square multiplied by the *gunaka* N and increased or diminished by a suitably chosen rational number k will be an exact square.

In other words, we shall have to obtain empirically a relation of the form

$$N\alpha^2 \pm k = \beta^2$$

where α , k , and β are rational numbers. Let us call this relation as the *Auxiliary Equation*. Then by Brahmagupta's Corollary, we get from it the relation

$$N(2\alpha\beta)^2 + k^2 = (\beta^2 + N\alpha^2)^2,$$

or
$$N\left(\frac{2\alpha\beta}{k}\right)^2 + 1 = \left(\frac{\beta^2 + N\alpha^2}{k}\right)^2$$

Hence, one rational solution of the equation $Nx^2 + 1 = y^2$ is given by

$$x = \frac{2\alpha\beta}{k}, \quad y = \frac{\beta^2 + N\alpha^2}{k}$$

Work on the rational solution of the Square-nature has been also done by Śrīpati. In fact, his solution, given in 1039 A.D. is of historical significance. He derives the rational solution without the aid of the "auxiliary equation." He gives the following rule :

Unity is the lesser root. Its square multiplied by the *prakṛti* is increased or decreased by the *prakṛti* combined with an (optional) number whose square-root will be the greater root. From them will be obtained two roots by the Principle of Composition¹

Thus if m^2 be the rational number optionally chosen, one shall have the identity :

$$N.1^2 + (m^2 - N) = m^2,$$

or

$$N.1^2 - (N - m^2) = m^2$$

Then by applying Brahmagupta's Corollary we get

$$N(2m)^2 + (m^2 \vee N)^2 = (m^2 + N)^2$$

$$\therefore N \left(\frac{2m}{m^2 \vee N} \right) + 1 = \left(\frac{m^2 + N}{m^2 \vee N} \right)^2$$

Hence

$$x = \frac{2m}{m^2 \vee N} \quad y = \frac{m^2 + N}{m^2 \vee N}$$

where m is any rational number, is a solution of the equation $Nx^2 + 1 = y^2$.

This rational solution of the *varga-prakṛti* which was used by Śrīpati in 1039 A.D. was rediscovered in Europe by Brouncker in 1657.

We shall close this discussion by taking an illustration from Bhāskara II :

Problem : Tell me, O mathematician, what is that square which multiplied by 8 becomes, together with unity, a square; and what square multiplied by 11 and increased by unity, becomes a square.

This means that we have to solve the equations :

$$8x^2 + 1 = y^2 \quad \dots\dots(i)$$

$$11x^2 + 1 = y^2 \quad \dots\dots(ii)$$

In the second example, let us assume 1 as the lesser root. Following the method of Śrīpati, let us multiply its square by the *prakṛti* (here in eq. ii, *prakṛti* is 11), then let us subtract 2 (an optional number) and then extracting the square-roots we

1. Śrīpati, *Śiddhanta-śekhara* XIV. 33

get the greater root as 3. Hence the statement for the composition is

$$\begin{array}{llll} m=11 & l=1 & g=3 & i=-2 \\ & l=1 & g=3 & i=-2 \end{array}$$

Here m =multiplier (*gunaka* or *prakṛti*), l =lesser root (*kaniṣṭha-mūla*), g =greater root (*jyeṣṭha-mūla*) and i =interpolator (*kṣepa*).

Here we have set down successively the lesser root, greater root and interpolator, and below them again set down the same (See Brahmagupta's Lemmas described by Bhāskara II). Now proceeding as before we obtain the roots for the additive 4 :

$$l=6, g=20, (\text{for}) i=4.$$

Then by the rule :

"If the interpolator (of a *varga-prakṛti* or Square-nature) divided by the square of an optional number be the interpolator (of another Square-nature), then the two roots (of the former) divided by that optional number will be the roots (of the other). Or, if the interpolator be multiplied, their roots should be multiplied."¹

are found the roots for the additive unity

$$l=3, g=10 (\text{for}) i=1.$$

Whence by the Principle of Composition of Equals, we get the lesser and greater roots : $l=60, g=199$ (for) $i=1$. In this way an infinite number of roots can be deduced.

Alternative method:-Bhāskara II has given another method for finding the two roots for the additive unity :

Or divide twice an optional number by the difference between the square of that optional number and the *prakṛti*. This (quotient) will be the lesser root (of a Square-nature) when unity is the additive. From that (follows) the greater root.²

-
1. इष्टवर्गहतः क्षेपः क्षेपः स्यादिष्टभाजिते ।
मूले ते स्तोऽथवा क्षेपः क्षुरणः क्षुरण्ये तदा पदे ॥

Bījagaṇita II. 5.

2. *Siddhānta-śekhara*, XIV. 32.

Let us solve the first example $8x^2+1=y^2$. We assume the optional number to be 3. Its square is 9; the *prakṛti* of multiplier is 8, their difference is $9-8=1$. Dividing by this twice the optional number (2×3 , i.e. 6), namely 6, we get the lesser root for the additive unity as 6. Whence proceeding as before, we get the greater to be 17. Thus here $x=6$ and $y=17$.

Let us use this method for the equation $11x^2+1=y^2$. Let the optional number be 3. Its square is 9; multiplier or *prakṛti* is 11; the difference is $11-9=2$; dividing by this twice the optional number (2×3), namely 6, we get $6/2=3$, which is the lesser root. Consequently the greater root would be 10, Thus for this equation $x=3$ and $y=10$.

Solution in Positive Integers

The Indian algebraists usually aimed at obtaining solutions of the *varga-prakṛti* or Square-nature in positive integers or *abhinna*. The tentative methods of Brahmagupta and Śrīpati always did not furnish solutions in positive integers. These authors, however, discovered that if the interpolator of auxiliary equation in the tentative method be ± 1 , ± 2 or ± 4 , an integral solution of the equation $Nx^2+1=y^2$ can always be found. Thus Śrīpati says :

If 1, 2 or 4 be the additive or subtractive (of the auxiliary equation), the lesser and greater roots will be integral (*abhinna*)¹.

(i) If $k=\pm 1$, then the auxiliary equation will be

$$Nx^2 \pm 1 = \beta$$

where α and β are integers. Then by Brahmagupta' Corollary we get

$$x=2\alpha\beta \text{ and } y=\beta^2+N\alpha^2$$

as the required first solution in positive integers of the equation $Nx^2+1=y^2$

1. इष्टवर्गं प्रकृत्योर्ध्वद्विवर्गं तेन वा भजेत् ।

द्विगुणमिष्टं कनिष्ठं तद् पदं स्यादेक संयुतौ ।

ततो ज्येष्ठमिष्टान्नख्यं भावनाभिस्तथेष्टतः ॥

(ii) Let $k=\pm 2$; then the auxiliary equation is

$$N\alpha^2 \pm 2 = \beta^2$$

By Brahmagupta's Corollary, we have

$$N(2\alpha\beta)^2 + 4 = (\beta^2 + N\alpha^2)^2$$

$$\text{or } N(\alpha\beta)^2 + 1 = \left(\frac{\beta^2 + N\alpha^2}{2} \right)^2$$

Hence the required first solution is

$$x = \alpha\beta, y = \frac{1}{2}(\beta^2 + N\alpha^2)$$

$$\text{Since } N\alpha^2 = \beta^2 \mp 2,$$

we have $\frac{1}{2}(\beta^2 + N\alpha^2) = \beta^2 \mp 1 = a$ whole number.

(iii) Now suppose $k = +4$: so that

$$N\alpha^2 + 4 = \beta^2$$

With an auxiliary equation like this, the first integral solution of the equation $Nx^2 + 1 = y^2$ is

$$x = \frac{1}{2}\alpha\beta$$

$$y = \frac{1}{2}(\beta^2 - 2);$$

if α is even; or

$$x = \frac{1}{2}\alpha(\beta^2 - 1)$$

$$y = \frac{1}{2}\beta(\beta^2 - 2);$$

if β is odd.

Thus we find Brahmagupta saying:

In the case of 4 as additive the square of the second root diminished by 3, then halved and multiplied by the second root will be the (required) second root: the square of the second root diminished by unity and then divided by 2 and multiplied by the first root will be the (required) first root (for the additive unity).¹

Datta and Singh has given the following *rationale* of this solution.

$$\text{Since } N\alpha^2 + 4 = \beta^2 \quad (i)$$

$$\text{we have } N(\alpha/2)^2 + 1 = (\beta/2)^2, \quad (ii)$$

Then by Brahmagupta's Corollary, we get

$$N(\alpha\beta/2)^2 + 1 = \left(\frac{\beta^2}{4} + N\frac{\alpha^2}{4} \right)^2$$

1. चतुरधिकेऽन्यपदकृतिस्त्र्यनादलिताऽन्यपद गुण्याऽन्यपदम् ॥

अन्यपद कृतिर्व्येकादि हताऽऽपधदाहताऽऽपधदम् ॥

Substituting the value of N in the right-hand side expression from (i), we have

$$N \cdot \left(\frac{\alpha\beta}{2} \right)^2 + 1 = \left(\frac{\beta^2 - 2}{2} \right)^2 \quad (\text{iii})$$

Composing (ii) and (iii),

$$N \left\{ \frac{\alpha}{2} (\beta^2 - 1) \right\}^2 + 1 = \left\{ \frac{\beta}{2} (\beta^2 - 3) \right\}^2$$

Hence $x = \frac{1}{2} \alpha\beta$, $y = \frac{1}{2} (\beta^2 - 2)$;

and $x = \frac{1}{2} \alpha(\beta^2 - 1)$, $y = \frac{1}{2} \beta(\beta^2 - 3)$;

are solutions of $Nx^2 + 1 = y^2$.

If β be even, the first values of (x, y) are integral. If β be odd, the second values are integral.

(iv) Finally, suppose $k = -4$; the auxiliary equation is

$$Na^2 - 4 = \beta^2$$

Then the required first solution in positive integers of

$$Nx^2 + 1 = y^2 \text{ is}$$

$$x = \frac{1}{2} \alpha\beta(\beta^2 + 3) (\beta^2 + 1)$$

$$y = (\beta^2 + 2) \left\{ \frac{1}{2} (\beta^2 + 3) (\beta^2 + 1) - 1 \right\}.$$

Brahmagupta says:

In the case of 4 as subtractive, the square of the second is increased by three and by unity; half the product of these sums and that as diminished by unity (are obtained). The latter multiplied by the first sum less unity is the (required) second root; the former multiplied by the product of the (old) roots will be the first root corresponding to the (new) second root.¹

The rationale of this solution, as given by Datta and Singh is as follows:

$$Na^2 - 4 = \beta^2 \quad (\text{i})$$

$$N(a/2)^2 - 1 = (\beta/2)^2$$

Hence by Brahmagupta's Corollary, we get

$$N \left(\frac{\alpha\beta}{2} \right)^2 + 1 = \left(\frac{\beta^2}{4} + N \frac{\alpha^2}{4} \right)^2$$

1. चतुस्तेऽन्यपद कृती ज्येकयुते वधदलं पृथग्येकम् ।

ज्येकावाहृतमन्त्यं पदवध गुणमावमान्यपदम् ॥

$$=\{\frac{1}{2}(\beta^2+2)\}^2 \quad (ii)$$

Again applying the Corollary, we get

$$N \{\frac{1}{2}a\beta(\beta^2+2)\}^2+1=\{\frac{1}{2}(\beta^4+4\beta^2+2)\}^2 \quad (iii)$$

Now by the Lemma we obtain from (ii) and (iii)

$$\begin{aligned} N \{\frac{1}{2}a\beta(\beta^2+3) (\beta^2+1)\}^2+1 \\ =[(\beta^2+2)\{\frac{1}{2}(\beta^2+3) (\beta^2+1)-1\}]^2 \end{aligned}$$

$$\text{Hence } x=\frac{1}{2}a\beta(\beta^2+3) (\beta^2+1),$$

$$y=(\beta^2+2) \{\frac{1}{2}(\beta^2+3) (\beta^2+1)-1\}$$

is a solution of $Nx^2+1=y^2$

This can be proved without difficulty that these values of x and y are integral. Since if β is even, β^2+2 is also even. And hence the above values of x and y are integral. On the other hand, if β is odd, β^2 is also odd; under these conditions β^2+1 and β^2+3 are even. In this also, therefore, the above values must be integral.

Putting $p=a\beta$, $q=\beta^2+2$, we can write the above solution in the form

$$x=\frac{1}{2}p(q^2-1).$$

$$y=\frac{1}{2}q(q^2-3).$$

This was the form in which the solution was found by Euler.

Cakravāla or Cyclic Method

We have shown in the preceding articles that the most fundamental step in Brahmagupta's method for the general solution in positive integers of the equation

$$Nx^2+1=y^2$$

where N is a non-square integer, is to form an auxiliary equation of the kind

$$Na^2+k=b^2$$

where a and b are positive integers and $k=\pm 1, \pm 2$ or ± 4 . From this auxiliary equation, by the Principle of Composition, applied repeatedly whenever necessary, one can derive, as we have already shown above, one positive integral solution of the original *Varga-prakṛti* or Square-Nature. And thence again, by means of the same principle, an infinite number of other solutions in integers can be obtained. How to form an auxiliary equation of

this type was a problem, write Datta and Singh, which could not be solved completely nor satisfactorily by Brahmagupta. In fact, Brahmagupta had to depend on trial. Success in this direction was, however, remarkably attained by Bhāskara II. He evolved a simple and elegant method which assisted in deriving an auxiliary equation having the required interpolator $\pm 1, \pm 2$, or ± 4 , simultaneously with its two integral roots, from another auxiliary equation empirically formed with any simple integral value of the interpolator, positive or negative. This method has been technically known as *Cakravāla* or the *cyclic method*. This is so called because it proceeds as in a circle, the same set of operations being applied again and again in a continuous round. For the details of this method, our reader is requested to consult the Algebra of Bhāskara II and the narrative on this method as given by Datta and Singh under the title "Cyclic Method" in their *History of Hindu Mathematics: Algebra*, 1962 Edition, pp. 161-72.

Solution of Indeterminate Quadratic Equation

It is remarkable to see that Brahmagupta was the first algebraist in the history of mathematics to find a general solution of the indeterminate quadratic equation

$$Nx^2 \pm c = y^2$$

in positive integers. We have the following verse in the *Brāhmasphuṭasiddhānta* in this connection:

From two roots (of a Square-nature or *varga-prakṛti*) with any given additive or subtractive, by making (combination) with the roots for the additive unity other first and second roots (of the equation having) the given additive or subtractive (can be found).¹

Let us take the following two equations:

$$a_1k = an + b; \text{ and } b_1k = bn + Na$$

From them we get : by eliminating n

$$a_1b - ab_1 = 1$$

1. रूप प्रद्वेपपदे पृथगिष्टत्वे व्यशोध्यमूलान्ध्याम् ।

इत्वाऽऽन्यपदे ये प्रद्वेपे ते ऽने ॥

Hence $b_1 = \frac{a_1 b - 1}{a} =$ a whole number.

$$\begin{aligned} \text{Now } n^2 - N &= \frac{(a_1 k - b)^2 - Na^2}{a^2} \\ &= \frac{a_1^2 k^2 - 2bka_1 + k}{a^2} \\ &= \frac{k(a_1^2 k - 2ba_1 + 1)}{a^2} \end{aligned}$$

Therefore $\frac{k}{a^2}(a_1^2 k - 2ba_1 + 1)$ is a whole number.

Since a, k have no common factor, it follows that

$$\frac{a_1^2 k - 2ba_1 + 1}{a^2} = \frac{n^2 - N}{k} = k_1 = \text{an integer.}$$

$$\begin{aligned} \text{Also } k_1 &= \frac{n^2 - N}{k} = \frac{a_1^2 k - 2ba_1 + 1}{a^2} \\ &= \frac{a_1^2(b^2 - Na^2) - 2ba_1 + 1}{a^2} \\ &= \left(\frac{a_1 b - 1}{a} \right)^2 - Na_1. \end{aligned}$$

Thus having known a single solution in positive integers of the equation $Nx^2 \pm c = y^2$, says, Brahmagupta, an infinite number of other integral solutions can be obtained by making use of the integral solutions of $Nx^2 + 1 = y^2$. If (p, q) be a solution of the former equation found empirically and if (α, β) be an integral solution of the latter, then by the principle of Composition

$$x = p\beta \pm q\alpha; y = q\beta \pm Np\alpha$$

will be a solution of the former. Repeating the operations, we can easily deduce as many solutions as we like.

$$\text{FORM } Mn^2x^2 \pm c = y^2:$$

In this connection, Brahmagupta says :

If the remainder is that divided by a square, the first root is that divided by its root¹.

This seems to mean that if we have the equation

$$Mn^2x^2 \pm c = y^2 \tag{i}$$

such that the multiplier (i.e. the coefficient of x^2) is divisible

1. कर्वाच्छिन्ने गुणके प्रथमं तन्मूलं भाजितं भवति ।

by n^2 , then we are justified in saying that if we put $nx=u$, the equation (i) becomes $Mu^2 \pm c = y^2$ (ii), and clearly the first root of (i) is equal to the first root of (ii) divided by n . The corresponding second root will be the same for both the equations.

$$\text{FORM } a^2x^2 \pm c = y^2 :$$

We find Brahmagupta giving the following rule in this connection: This is a solution of a particular form of a *varga-prakṛti* or Square-nature.

If the multiplier be a square, the interpolator divided by an optional number and then increased and decreased by it, is halved. The former (of these results) is the second root; and the other divided by the square-root of the multiplier is the first root.¹

Thus the solutions of the equation

$$a^2x^2 \pm c = y^2$$

are :

$$x = \frac{1}{2a} \left(\frac{\pm c}{m} - m \right)$$

$$y = \frac{1}{a} \left(\frac{\pm c}{m} + m \right)$$

where m is an arbitrary number.

Bhāskara II and Nārāyaṇa have also given the same solutions as proposed by Brahmagupta.

Rational Geometrical Figures

In the days of the *Taittiriya Samhitā* and the *Śatapatha Brahmana*, Indian mathematicians got familiarity with the solution of such equations

$$x^2 + y^2 = z^2$$

and the results were arrived geometrically on the basis of the law of rectangle as propounded by Baudhāyana in the *Śulba Sūtras* and which goes by his name. The reader is referred to the Chapter on Baudhāyana, the first Geometer in the author's "*Founders of Sciences in Ancient India*". Baudhāyana (c. 800 B.C.) gave a

1. कौ गुणके चोपः केनचिद्वृत्त्युतो नितो दलितः ।

प्रथमोऽन्यमूलमन्व्यो गुणकारपदोद्धृतः प्रथमः ॥

method of transforming a rectangle into a square, which is equivalent to the algebraic identity :

$$mn = \left(m - \frac{m-n}{2}\right) - \left(\frac{m-n}{2}\right)$$

where m, n , are any two arbitrary numbers.

Brahmagupta in connection with the solution of rational triangles says :

The square of the optional (*iṣṭa*) side is divided and then diminished by an optional number; half the result is the upright, and that increased by the optional number gives the hypotenuse of a rectangle.

We shall put these statements of Brahmagupta in the algebraic language thus : If m, n be any two rational numbers, then the sides of a right-angled triangle will be

$$m, \frac{1}{2} \left(\frac{m^2}{n} - n \right), \frac{1}{2} \left(\frac{m^2}{n} + n \right)$$

This Sanskrit term *iṣṭa* may either mean "given" or "optional". With the former meaning the rule would imply the method of finding rational right angles having a given leg.

Brahmagupta was the first to give a solution of the equation $x^2 + y^2 = z^2$ in integers. His solution is

$$m^2 - n^2, 2mn, m^2 + n^2.$$

m and n being two unequal integers.²

Thus if $m=7$ and $n=4$, then $m^2 - n^2 = 33$, $2mn = 56$ and $m^2 + n^2 = 65$; then the three numbers 33, 56 and 65 bear the relation $33^2 + 56^2 = 65^2$.

Mahāvīra (850 A.D.) also states

The difference of the squares (of two elements) is the upright, twice their product is the base and the sum of their squares is the diagonal of a *generated* rectangle.²

Isosceles Triangles with Integral Sides : The following statement of Brahmagupta in this connection is very significant :

1. इष्टस्य मुजस्य कृतिर्मेको नेष्टेन तद्वलं कोटिः ।

आयतचतुरस्रस्य द्वे त्रस्येष्टाधिका कर्षः ॥

—BrSpSi. XII. 35

2. GSS. VII. 90½

The sum of the squares of two unequal numbers is the side; their product multiplied by two is the altitude, and twice the difference of the squares of those two unequal numbers is the base of an isosceles triangle.¹

Thus if m, n be two integers such that m is not equal to n , the sides of all rational isosceles triangles with integral sides are given by

$$m^2 + n^2, m^2 + n^2, 2(m^2 - n^2)$$

and the altitude of the triangle is $2mn$.

This method was also followed by Mahāvīra and other Indian mathematicians. In fact, their solutions are based on the juxtaposition of two rational right triangles, equal so that they have a common leg. It is remarkably a powerful device, for every rational triangle or quadrilateral may be formed by the juxtaposition of two or four rational right triangles.

Isosceles Triangles with a Given Altitude

Here we have a rule given by Brahmagupta for finding out all rational isosceles triangles possessing the same altitude :

The (given) altitude is the producer (*karana*). Its square divided by an optional number is increased and diminished by that optional number. The smaller is the base and half the greater is the side.²

Thus if m be any rational number then for a given definite altitude a , the sides of the rational isosceles triangles are $\frac{1}{2} \left(\frac{a^2}{m} + m \right)$ each and the base is $\frac{a^2 - m^2}{m}$. We shall illustrate it by an example taken from the commentary of Pṛthūdaka Svāmī. The given altitude is 8; let us take any rational number $m=4$ then the two equal sides of the isosceles are given by $\frac{1}{2} \left(\frac{8^2 + 4^2}{4} \right) = 10$ each and the base is $\frac{8^2 - 4^2}{4} = 12$. Thus the three sides of the

1. कृति युतिर सदृशराशयोर्बाहुर्धातो द्विसंयुतो लम्बः ।

कृत्यन्तरमसदृशयोर्द्विगुणं द्विसमन्विमुज भूमिः ॥

—BrSpSi. XII. 33

2. करणी लम्बस्तत्कृतिरिच्छतेऽथेन संयुताऽल्पा भूः ।

अधिको द्विह तो बाहुः संचे प्यो यद्वयो कर्माः ॥

—BrSpSi. XII. 37.

rational isosceles triangle with altitude 8 are (10,10, 12).

Rational Scalene Triangles: Brahmagupta lays down the following rule in the case of rational scalene triangle ;

The square of an optional number is divided twice by two arbitrary numbers; the moieties of the sums of the quotients and (respective) optional numbers are the sides of a scalene triangle; the sum of the moieties of the differences is the base.¹

In other words, if m, p, q are any rational numbers, then the sides of a rational scalene triangle are :

$$\frac{1}{2} \left(\frac{m^2}{p} + p \right), \frac{1}{2} \left(\frac{m^2}{q} + q \right),$$

$$\frac{1}{2} \left(\frac{m^2}{p} - p \right) + \frac{1}{2} \left(\frac{m^2}{q} - q \right)$$

Here the altitude (m), area and segments of the base of this triangle are all rational.

Thus putting $m=12, p=6$, and $q=8$ in Brahmagupta's general equation, Pṛthūdaka Svāmī derives a scalene triangle with sides (13,15) and (14) altitude (12), area (84 and the segments of the base (5) which are all integral numbers.

$$\frac{1}{2} \left(\frac{m^2}{p} + p \right) = \frac{1}{2} \left(\frac{12^2}{6} + 6 \right) = 15;$$

$$\frac{1}{2} \left(\frac{m^2}{q} + q \right) = \frac{1}{2} \left(\frac{12^2}{8} + 8 \right) = 13$$

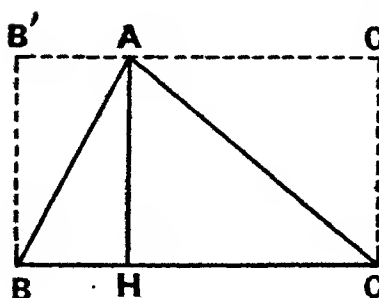


Fig. 19

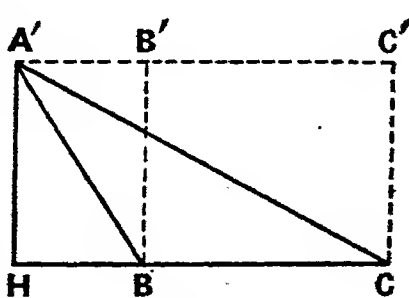


Fig. 20

1. इष्टद्वयेन भक्तौ द्विषेष्ट वर्गं फलेष्टयोगार्थे ।
विषमत्रिभुजस्य भुजाविष्ट्येन फलार्थयोगो भूः ॥

Thus the two sides of the rational scalene triangle are 15 and 13. The base is.

$$\frac{1}{2} \left(\frac{12^2}{6} - 6 \right) + \frac{1}{2} \left(\frac{1^2}{8} - 8 \right) = 9 + 5 = 14$$

The altitude is $m=12$; area is equal to $\frac{\text{base} \times \text{altitude}}{2}$

$$= \frac{14 \times 12}{2} = \text{and the segments are } \sqrt{13^2 - 12^2} = 5 \text{ and}$$

$$\sqrt{(15^2 - 12^2)} = 9. \text{ Thus they are all integers.}$$

Rational Isosceles Trapeziums

Brahmagupta has given us a method of obtaining such isosceles trapeziums whose sides, diagonals, altitude, segments and area are all rational numbers. His rule is as follows:

The diagonals of the rectangle (generated) are the flank sides of an isosceles trapezium; the square of its side is divided by an optional number and then lessened by that optional number and divided by two; (the result) increased by the upright is the base and lessened by it is the face.¹

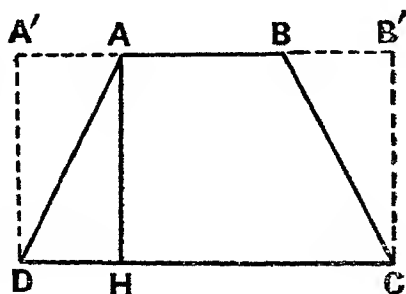


Fig. 21

Here in the figure, we have the isosceles trapezium ABCD of which CD is the base and AB is known as the face. According to Brahmagupta's rule, we have (p being the optional number).

$$CD = \frac{1}{2} \left(\frac{4m^2n^2 - p}{p} \right) + (m^2 - n^2) \quad (\text{base})$$

$$AB = \frac{1}{2} \left[\frac{4m^2n^2}{p} - p \right] - (m^2 - n^2) \quad (\text{face})$$

$$DH = (m^2 - n^2) \quad (\text{upright})$$

1. आहतकर्षो वाहू मुजकृतिरिष्टेन भाजितेष्टोना ।

दिहता कोट्यधिका भूमि खमना दिसमचतुरस्रे ॥

$$AD = BC = m^2 + n^2 \quad (\text{the sides of the trapezium})$$

$$HC = \text{base-upright} = \frac{1}{2} \left[\frac{4m^2n^2}{p} - p \right] \quad (\text{segment})$$

$$AC = BD = \left[\frac{4m^2n^2}{p} + p \right] \quad (\text{diagonal})$$

$$AH = 2mn \quad (\text{altitude})$$

$$ABCD = mn \left[\frac{4m^2n^2}{p} - p \right] \quad (\text{area})$$

By choosing the values of m , n and p suitably, the values of all the dimensions of the isosceles trapezium can be made integral. *Prthūdaka Svāmī* starts with the rectangle (5, 12, 13) and suitably takes p as 6; then he calculates out the dimensions of the trapezium: flank sides (AD and BC) = 13, base = 14, and altitude (AH) = 12, segments of base (DH and HC) = 5, and 9, diagonals (AC and BD) = 15, area $ABCD$ = 108. All these values are integers.

In this example, the rectangle chosen is (5, 12, 13) which is $AA'DH$, where $AD = m^2 + n^2 = 13$

$$\text{and } DH = m^2 - n^2 = 5$$

whence by adding the two we have

$$2m^2 = 18$$

This gives the value of $m = 3$, and hence $n = 2$. *Prthūdaka Svāmī* has taken the value of $p = 6$ by choice. Putting these values of m , n and p , the values for the dimensions of the isosceles trapezium follow from the expressions given by *Brahmagupta*.

$$CD = \frac{1}{2} \left(\frac{4 \cdot 3^2 \cdot 2^2}{6} - 6 \right) + \left(3^2 - 2^2 \right) = 9 + 5 = 14 \text{ (base)}$$

$$\text{Face} = 9 - 5 = 4$$

$$\text{Sides } AD = BC = 3^2 + 2^2 = 13$$

and so on for the other dimensions.

Rational Trapeziums With Three Equal Sides

This problem is very much the same as one of the rational isosceles trapezium with the only difference that in this case one of the parallel sides is also equal to the slant sides. We

have the following solution of this problem from Brahmagupta :

The square of the diagonal (of a *generated* rectangle) gives three equal sides; the fourth (is obtained) by subtracting the square of the upright from thrice the square of the side (of that rectangle). If greater, it is the base; if less, it is the face.¹

As before, the rectangle generated from m, n is given by $(m^2-n^2, 2mn, m^2+n^2)$, that is these are the three sides of the right triangle, which correspond to the two sides and the diagonal of the rectangle generated by them. Let us suppose, we have a trapezium ABCD whose sides AB, BC and AD are equal, then

$$AB = BC = AD = (m^2+n^2)^2$$

$$CD = 3(2mn)^2 - (m^2-n^2)^2 = 12m^2n^2 - m^4 - n^4$$

$$\text{or } CD = 3(m^2-n^2)^2 - (2mn)^2 = 3m^4 + 3n^4 - 10m^2n^2.$$

Prthūdaka Svāmī has taken an illustration, where $m=2$, $n=1$ and he deduces two rational trapeziums with three equal sides (25, 25, 25, 39) and (25, 25, 25, 11).

The segment (CH), altitude (AH), diagonals (AC, BD) and area of this trapezium are also rational, and given by :

$$CH \text{ (segment) } = 6m^2n^2 - m^4 - n^4$$

$$AH \text{ (altitude) } = 4mn(m^2-n^2)$$

$$AC = BD \text{ (diagonals) } = 4mn(m^2+n^2)$$

$$ABCD \text{ (area) } = 32m^3n^3(m^2-n^2).$$

Rational Inscribed Quadrilaterals

We find in the *Brahmasphuṭasiddhānta* a remarkable proposition formulated by Brahmagupta :

To find all quadrilaterals which will be inscribable within circles and whose sides, diagonals, perpendiculars, segments (of sides and diagonals by perpendiculars from vertices as also of diagonals by their intersection), areas, and also the diameters of the

1. कर्षकृतिस्त्रिसम मुखास्त्रयश्चतुर्थो विशेष्य कोटि कृतिम् ।

बाहुकूटरेस्त्रियुखाया वचधिको भूमुसं द्वीनः ॥

circumscribed circles will be expressible in integers. Such quadrilaterals we shall call as *Brahmagupta Quadrilaterals*.

The solution of this formidable problem has been given by Brahmagupta as follows :

The upright and bases of two right-angled triangles being reciprocally multiplied by the diagonals of the other will give the sides of a quadrilateral of unequal sides : (of these) the greatest is the base, the least is the face, and the other two sides are the two flanks.¹

Taking Brahmagupta's integral solution, the sides of the two right triangles of reference are given by :

$$(1) \quad m^2 - n^2, 2mn, m^2 + n^2;$$

$$(ii) \quad p^2 - q^2, 2pq, p^2 + q^2;$$

where m, n, p, q are integers. Then the sides of the *Brahmagupta Quadrilateral* are.

$$(m^2 - n^2)(p^2 + q^2), (p^2 - q^2)(m^2 + n^2), \\ 2mn(p^2 + q^2), 2pq(m^2 + n^2) \quad (\text{Arrangement A})$$

Prthudaka Svāmī has illustrated the rational inscribed quadrilateral by taking an example of the right angle triangles.

$$(i) \quad (3,4,5) (m^2 - n^2 = 3, \\ m^2 + n^2 = 5, \text{ whence } \\ m=2, n=1)$$

$$(ii) \quad (5,12,13) (p^2 - q^2 = 5, \\ p^2 + q^2 = 13, \text{ whence } \\ p=3, q=2)$$

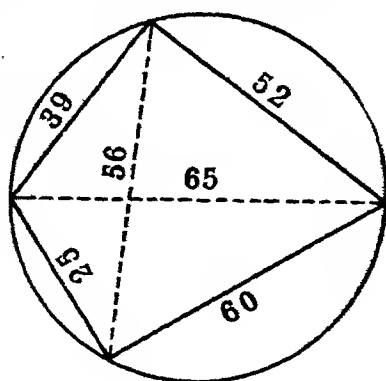


Fig. 22

Substituting these values in the above equations, we get the sides of the quadrilateral as (39, 25, 52 and 60).²

1. जात्यद्वय कोटिमुजाः परकार्यगुणा मुजाश्चतुर्विधमे ।

अधिको भूमुखदीनो बाहुद्वितय मुजावन्त्यौ ॥

—BrSpSi. XII. 38

2. The diagonals of this quadrilateral are given by Bhāskara II as 56 (=3.12+4.5) and 63 (=4.12+3.5).

(Cont. on page 268)

Put in other words, this means that one has to solve the following equations :

$$(i) \quad 5x-25 = y^2$$

$$(ii) \quad 10x-100 = y^2$$

$$(iii) \quad 83x-7635 = y^2$$

Prthūdaka Svāmī, the commentator on the *Brāhmasphuṭa-siddhānta* proceeds to solve these equations as follows :

(1.1) Suppose $y = 10$; then $x = 125$. Or put $y = 5$; then $x = 10$.

(2.1) Suppose $y = 10$; then $x = 20$.

(3.1) Assume $y = 1$; then $x = 92$.

He then remarks that by virtue of the multiplicity of suppositions there will be an infinitude of solutions in every case, But no method has been given either by Brahmagupta or his commentator to obtain the general solution.

Double Equations of the First Degree

Perhaps we have the earliest reference of the simultaneous indeterminate quadratic equations of the type

$$x \pm a = u^2$$

$$x \pm b = v^2$$

in the *Bhaskārāli Manuscript* (Folio 59, recto).

Brahmagupta gives the solution of such simultaneous indeterminate quadratic equations of a general case as follows :

The difference of the two numbers by the addition or subtraction of which another number becomes a square, is divided by an optional number and then increased or decreased by it. The square of half the result diminished or increased by the greater or smaller (of the given number) is the number (required).¹

Expressed in the language of algebra, shall have :

$$= \frac{1}{4} \left\{ \frac{1}{2} \left(\frac{a-b}{m} \pm m \right) \right\}^2 \mp a$$

1. यास्यां कृतिरधिको नस्तदन्तरं हत युतो न मिष्टेन ।

तद्वल कृतिरधिकोनाऽधिकयो रधिको न यो राशिः ॥

$$\text{or } x = \left\{ \frac{1}{2} \left(\frac{a-b}{m} \mp m \right) \right\}^2 \mp b$$

where m is an arbitrary number.

Datta and Singh has given the *rationale* of this method as follows :

$$u^2 = x \pm a; \quad v^2 = x \pm b,$$

$$\text{From them, we have } u^2 - v^2 = \pm a \mp b$$

$$\text{Therefore } u - v = m$$

$$\text{and } u + v = \frac{\pm a \mp b}{m},$$

where m is arbitrary. Hence

$$u = \frac{1}{2} \left(\frac{\pm a \mp b}{m} + m \right) = \pm \frac{1}{2} \left(\frac{a-b}{m} \pm m \right)$$

Since it is obviously immaterial whether u is taken as positive or negative, we have

$$u = \frac{1}{2} \left(\frac{a-b}{m} \pm m \right)$$

$$\text{Similarly } v = \frac{1}{2} \left(\frac{a-b}{m} \mp m \right)$$

$$\text{Therefore } x = \left\{ \frac{1}{2} \left(\frac{a-b}{m} \pm m \right) \right\}^2 \mp a,$$

$$\text{or } x = \left\{ \frac{1}{2} \left(\frac{a-b}{m} \mp m \right) \right\}^2 \mp b,$$

where m is an arbitrary number.

Now we shall take up another particular case, for which Brahmagupta has given a rule :

The sum of the two numbers the addition and subtraction of which make another number (severally) a square, is divided by an optional number and then diminished by that optional number. The square of half the remainder increased by the subtractive number is the number (required)¹.

In the algebraic notations, we shall express it as follows :

1. यैरुनो यैरच युतो रूपैर्वर्गस्तदैवयमिष्ट हतम् ।
इष्टोनं तद्वल कृतिरुनाऽभ्यधिका भवति राशिः ॥

$$y = \frac{1}{a} \left(\frac{ad+bc}{m} + b \right)$$

if $b > c$ and $m > \frac{ad+bc}{m}$. If these conditions be reversed then x and y will have their values interchanged.

Datta and Singh have given the following *rationale* of these solutions :

$$axy = bx + cy + d,$$

$$\text{or } a^2xy - abx - acy = ad,$$

$$\text{or } (ax-c)(ay-b) = ad+bc.$$

Suppose $ax-c = m$, a rational number;

$$\text{then } ay-b = \frac{ad+bc}{m}.$$

Therefore,

$$x = \frac{1}{a}(m+c)$$

$$y = \frac{1}{a} \left(\frac{ad+bc}{m} + b \right)$$

Or, we may put $ay-b = m$;

in that case, we shall have $ax-c = \frac{ad+bc}{m}$;

$$\text{whence } x = \frac{1}{a} \left(\frac{ad+bc}{m} + c \right),$$

$$y = \frac{1}{a}(m+b).$$

Brahmagupta's own rule.

Whilst the rule given above is ascribed to an unknown author, Brahmagupta's own rule for the solution of a quadratic indeterminate equation involving a factum is as follows :

With the exception of an optional unknown, assume arbitrary values for the rest of the unknowns, the product of which forms the factum. The sum of the product of these (assumed values) and the (respective) coefficients of the unknowns will be absolute quantities. The continued products of the assumed values and of the coefficient of the factum will be the coefficient of the optionally (left out) unknown. Thus the solution

is effected without forming an equation of the factum
Why then was it done so ?¹

Datta and Singh think that the reference in the latter portion of this rule is to the method of the unknown author :

"*Kim krtam tadatah*" ? The principle underlying Brahmagupta's method is to reduce, like the Greek Diophantus (c.275 A.D.), the given indeterminate equation to a simple determinate one by assuming arbitrary values for all the unknowns except one. So undoubtedly it is inferior to the earlier method.

We now take an illustrative example from Brahmagupta :

On subtracting from the product of signs and degrees of the Sun, three and four times (respectively) those quantities, ninety is obtained. Determining the Sun within a year (one can pass as a proficient) mathematician.

If we presume x to denote the signs and y the degrees of the Sun, then the equation would be :

$$xy - 3x - 4y = 90$$

Prthūdaka Svāmī solves it in two ways :

(i) Let us assume the arbitrary number to be 17. then

$$x = \frac{1}{17} \left(\frac{90.1 + 3.4}{17} + 4 \right) = 10$$

$$y = \frac{1}{17} (17 + 3) = 20$$

(ii) Let us assume arbitrarily $y = 20$. On substituting this value of y in the above equation, we get

$$20x - 3x = 170$$

$$\text{whence } x = 10.$$

1. भावितके यद्घातो विनष्टवर्णेन तत्प्रमाणानि ।
कृत्वेष्टानि तदाहृत वर्णैक्यं भवति रूपाणि ॥
वर्णं प्रमाणभाविता घातो भवतीष्ट वर्णं संख्यैवन् ।
सिध्यति विनाऽपि भावित-उभकरणात् किं कृत् तदतः ॥ —BrSpSi. XVIII. 62-63
2. भानो राश्यशवधत् त्रिचतुर्गुणितान् विशोध्य राश्यशान् ।
नवतिं दृष्ट्वा सूर्यं कुर्वन्नावत्सराद् गणकः ॥ —BrSpSi. XVIII. 61.

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- B. Datta and A.N. Singh : *History of Hindu Mathematics* Pt. I and II, 1962.

Arabic and Indian Divisions of the Zodiac

It has long been a debated question whether the Indian and Arabian divisions of the zodiac had a common origin. Sir William Jones thought that they had not; but Colebrooke holds a contrary view. The coincidence, in the two systems of division is so exact that he thinks, it could not be due to chance. Colebrooke has discussed this point in details in one of his Papers entitled "On the Indian and Arabian divisions of the zodiac", *Asiatic Researches* Vol. ix. p. 323-376, reproduced in the *Miscellaneous Essays*, Vol. II. p. 321-373, 1872.

1. *Āsvini*, now the first *nakṣatra*, but anciently, the last but one, probably obtained its present situation at the head of the asterisms, when the beginning of the zodiac was referred to the first degree of Meṣa (the Ram). As measuring a portion of the zodiac, it occupies the first $13^{\circ}20'$ of Meṣa; and its beginning follows immediately after the principal star in the last *nakṣatra* Revati, reckoned by some exactly, by others nearly, opposite to the very conspicuous one, which forms the fourteenth asterism. As a constellation, *Āsvini* comprises three stars (Aries α , β , γ) figured as a horse-head; and the principal, which is also the northern one, is stated by all ancient authorities, in 10° N and 8° E. from the beginning of the Meṣa.

According to Arabs, the first manzil or lunar mansion is entitled *Sheratan*, (by Persians, *Sheratain*), and comprises two stars of the third magnitude on the head of Aries, in lat. $6^{\circ}36'$ and $7^{\circ}51'$ N and long. $26^{\circ}13'$ and $27^{\circ}7'$. With the addition of a

third, also in the head of the Ram, the asterism is denominated *Āshrait*. The bright star of the second or third magnitude which is out of the figure of the Ram, according to Ulugh Beg, but on the nose according to Hipparchus, cited by this author from Ptolemy, is determined *Nātih* : It is placed in lat. $9^{\circ}30'N$ and long. $1^{\circ}0'43'$, and is apparently the same with the principal star of the Indian asterism; for Muhammad of Tizin, in his table of declination and right ascension, expressly terms it the first star of the *Sheratain*.

2. *Bharani*, the second asterism, comprises three stars (35, 39, 41 Aries) figured by the *yonī* or *pudendum muliebre* and the principal and southern star of this *nakṣatra* is placed in $12^{\circ}N$. On the Arabian system, the second manzil, entitled *Butain* is placed by Ulugh Beg in lat. $1^{\circ}12'$ and $3^{\circ}12'$, and this cannot possibly be reconciled with the Indian constellation. But Muhammad of Tizin assigns to the bright star of *Butain* a declination of $23^{\circ}N$ exceeding by nearly 2° the declination allotted by him to *Nātih* or his first star in *Sheratain*. This agrees with the difference between the principal stars of *Āsvini* and *Bharani*; and it may be inferred, that some among the Mohammadan astronomers have concurred with the Hindus, in referring the second constellation to stars that form Musca.

3. *Kṛttikā*, now the third, formerly the first, *nakṣatra* consists of six stars figured as knife or razor, and the principal and southern star is placed in $4\frac{1}{2}^{\circ}$ or $5^{\circ}N$ and in 65 sixths of degrees (or $10^{\circ}50'$) from its own commencement (cf. the *Sūryasiddhānta*), or $37^{\circ}28'$ to 38° from the beginning of the Meṣa (the *Siddhānta-Siromani* or the *Graha Laghava*) respectively. This longitude of the circle of declination corresponds nearly with that of the bright star in the Pleiades, which is 40° of longitude distant from the principal star of *Revati*.

The stars indicated by Ulugh Beg for *Thurayyā*, also correspond exactly with the Pleiades.

4. *Rohini*, is the fourth *nakṣatra*, the Arabic name for the fourth mansion is *Debarān* (or with the article *Aldebarān*). It corresponds to the bright star called the Bull's eye, and which is unquestionably the same with the principal and eastern star of *Rohini*, placed in $4\frac{1}{2}^{\circ}$ or $5^{\circ}S$ and $49\frac{1}{2}^{\circ}E$ by the Hindu writers on Astronomy. This *nakṣatra* is

figured as a wheel cart, and comprises five stars, out of the seven which the Greeks named the Hyades. The Arabs, however, like the Hindus, reckon five stars only in the asterism. Sir William Jones supposes them to be in the head and neck of the Bull; they probably are $\alpha, \rho, \gamma, \delta, \epsilon$ Tauri, agreeably to Mons. Bally's conjecture.

5. *Mṛgashīrā*, the fifth *nakṣatra*, represented by an antelope head, contains three stars; the same which constitute the fifth lunar mansion *Hakāh*; for the distance of 10° S assigned to the northern star of this *nakṣatra*, will agree with no other but one of the three in the head of Orion. The difference of longitude (24° to $25\frac{1}{2}^{\circ}$) from *Kṛttikā* corresponds with sufficient exactness; and so does the longitude of its circle of declination (62° to 63°) from the end of *Rewatī*; since the true longitude of λ Orionis, from the principal star in *Revatī* (ζ piscium) is $63\frac{1}{2}^{\circ}$.

6. *Ārdrā*, the sixth *nakṣatra*, consists of a single bright star, described as a gem, and placed in 9° S (by some in 11°) and at the distance of $4\frac{1}{2}$ to 4° in longitude from the last asterism. This indicates the star in the shoulder of Orion (α orionis). The sixth lunar mansion, is named by the Arabs as *Hanāh*; and comprises two stars in the feet of the second twin, according to Ulugh Beg, though others make it to be a shoulder. Mohammad of Tizin allots five stars to this constellation; and the Kāmūs, among various meanings of *Hanāh*, says, that it is a name for five stars in the left arm of Orion; remarking also, that the lunar mansion is named *Tahāyi*, comprising three stars called *Tahyāt*. Obviously here the Indian and Arabian asterisms are irreconcilable.

7. *Punarvasū* (used in a dual number) is the seventh *nakṣatra*, and is represented by a house, or even a bow, and it includes four stars, among which the principal and eastern one is 30° or 32° from the fifth asterism; but has been placed by all authorities in 6° N. This agrees with (β Geminorum) one of the two stars in the heads of the Twins, which together constitute the seventh lunar mansion *ziraā*, according to Mohammad of Tus and Mohammad of Tizin and other Arabian authorities. The seventh lunar mansion of Arabs is named *ziraā ul ased* according to Jauhari and other cited by Hyde in his *Commen-*

tary on Ulugh Beg. and that the *Kamūs* makes this term to be the name of eight stars in the form of a bow.

8. *Puṣya*, the eighth asterism, is described as an arrow, and consists of three stars the chief of which being also the middle most, has no latitude, and is 12° to 13° distant from the seventh asterism, being placed by Hindu astronomers in 106° of longitude. This is evidently δ Cancer; and does not differ widely from the eighth lunar mansion *Nethrah*, which according to Ulugh Beg and others consists of two stars, including the nebula of Cancer. The Indian constellation comprises two other stars besides δ Cancer, which are perhaps γ and β of the same constellation.

9. *Asleṣa*, the ninth asterism, contains five stars figured as a potter's wheel, and of which the principal or eastern one is placed in 7° S. and according to different tables, 107° , 108° or 109° E. This appears to be intended for the bright star in the southern claw of Cancer (α Cancer), and cannot be reconciled with the lunar mansion *Tarf* or *Tarfah*, which comprises two stars near the lion's (simha) eye, the northernmost being placed by Mohammad of Tizin in 24° of N. declination.

10. *Maghā*, the tenth asterism, contains like the last, five stars, but which are figured as a house. The principal of the Southern one has no latitude; and according to all authorities, has 129° longitude. This is evidently Regulus (α Leonis): which is exactly 129° distant from the last star in *Revati*. The tenth lunar mansion of Arabians is *Jebhaḥ*, which comprises three (some say, four) stars, nearly in the longitude of the lion's heart. In this instance, therefore, the Indian and Arabian divisions of the zodiac coincide. This *nakṣatra* consists of α , γ , δ and ν Leonis.

11. *Pūrva-Phalguni* is the eleventh *nakṣatra* and is represented by a couch or bedstead; it consists of two stars determined by the place of the chief star (the northernmost, according to the *Sūrya-Siddhānta*) in 12° N and 144° E. or according to Brahmagupta, the *Śiromani* and the *Grahalaghava*, 147° or 148° E. They are probably δ and θ Leonis. The Arabian name for this lunar mansion is *zubrah* or *Khertān*.

It may be mentioned here that Brahmagupta and Bhāskara selected the southern for the principal star; while the *Sūrya-Siddhānta* took the northern. Hence the latitude stated by several Hindu authorities is the mean between both stars; and the difference of longitude, compared to the preceding and subsequent asterisms, may be exactly reconciled upon this supposition.

12. *Uttara-Phālgunī*, which is the twelfth *nakṣatra*, consists of two stars, and is figured as a bed or cot. These stars are ascertained by the place of one of them (the northernmost) 13° N. and 155° E. This indicates β Leonis; the same which singly constitutes the Arabian Lunar mansion *Serfah*, though Mohamad of Tizīn seems to hint that it consists of more than one star.

13. *Hasta*, the thirteenth *nakṣatra*, has the name and figure of a hand; and is suitably made to contain five stars. The principal one towards the west, next to the north-western star, is placed according to all authorities in 11° and 170° E. This can only belong to the constellation Corvus; and accordingly five stars in that constellation (α , β , γ , δ and ϵ Corvi). The thirteenth lunar mansion of Arabs is *Awwa*, which is also described to contain five stars, situated under Virgo and so disposed as to resemble the letter *Alif*. They are placed by Ulugh Beg in the wing. Here obviously, there is nothing common between the Hindu and Arabian specification of the asterism. The agreement is only in the number of stars and in the longitude.

14. *Citrā*, the fourteenth *nakṣatra*, is figured as pearl. It is placed by the *Sūrya-Siddhānta* in 2° S and 180° E. and by Brahmagupta, the *Śiromaṇi* and *Grahalāghava* in $1\frac{1}{4}$ or 2° S and 183° E. This agrees with the Virgin's spike (α Virginis). The same star constitutes the fourteenth lunar mansion of the Arabs named from it *Simāc ul aāzi*.

15. *Svāti*, the fifteenth *nakṣatra*, is represented by a coral bead. The *Sūrya-Siddhānta*, Brahmagupta, the *Śiromaṇi* and *Grahalāghava*, all concur in placing it at 37° N. They differ one degree in longitude of its circle of declination, three of them

making it 199° and the other 198° . The Indian asterism totally disagrees with the lunar mansion *Ghafr* which is the fifteenth Arabian mansion, and which consists of three stars in the Virgin's (*Kanyā*) foot, according to Ulugh Beg. but in or near the balance (*Tulā*), according to others.

16. *Viśakhā*, the sixteenth *nakṣatra*, consists of four stars described as a festoon. All the authorities place the principal and northernmost star in $1^\circ, 1^\circ 20'$ or $1^\circ 30'$ S and in $212^\circ, 212^\circ 5'$ or 213° E. The latitude seems to indicate the bright star in the Southern Scale (α Librae), though the longitude disagrees (suggesting possibly a remote star κ Librae). Colebrooke suggests the four stars to be α ν ι Librae and γ Scorpii. The sixteenth lunar mansion according to Arabs is *Zubānah* or *Zubāniyah* according to Mohammad of Tizin, the bright star in the northern scale (β Librae).

17. *Anurādhā*, the seventeenth *nakṣatra*, consists of four stars and is described as a row of oblations in a right line. Its chief or middlemost star is placed in 3° , or 2° or $1^\circ 45'$ S and in 224° or $224^\circ 5'$ E, thus placing it near the head of the Scorpion (*Vṛścika*) (δ Scorpionis) and the asterism comprises β , δ , π , and ρ Scorpionis. The seventeenth lunar mansion of Arabs is called *Iklīl* or *Iklīl-l-jebbah*, which is said to contain 4, 3, or 6 stars lying in a straight line. Those assigned by Ulugh Beg for this mansion are β , δ , ν and π Scorpionis. Thus here the Indian and Arabian astronomers both concur exactly.

18. *Jyesthā*, the eighteenth *nakṣatra*, comprises three stars figured as a ring. The principal and middlemost star is placed in $4^\circ 3\frac{1}{2}'$ or 3° S and in $229^\circ, 229^\circ 5'$ or 230° E; this position indicates Antares or the Scorpion's heart (α Scorpionis), which is also the eighteenth lunar mansion, named *Kalb* or *Kalbul'akrab*. The three stars of Indian asterism may be α , σ and τ Scorpionis.

19. *Mūla*, the nineteenth *nakṣatra*, is represented by a lion's tail, and it contains eleven stars, of which the characteristic one, the easternmost, is placed in $9^\circ, 8\frac{1}{2}'$ or 8° S and in 241° or 242° E. This probably (not exactly) indicates ν Scorpionis. This agrees with the eighteenth lunar mansion of Arabs known as *Shaulah*, consisting of two stars near the Scorpion's

sting. The Hindu asterism probably includes all the stars in the Scorpion's tail (ϵ , μ , ζ , η , θ , ι , κ , λ , ν and ν Scorpionis).

20. *Pūrva-Āṣāḍha*, the twentieth *nakṣatra*, is figured as an elephant's tooth or as a couch, and it consists of two stars, of which the most southern one is placed in $5\frac{1}{2}^{\circ}$, $5\frac{1}{3}$ or 5° S and 254° or 255° E. This corresponds well with δ Sagittarii, and which also corresponds with the twentieth lunar mansion of Arabs called *Nāaim*. The Arabian mansion consists of four, or according to some eight, stars. The Indian *nakṣatra* corresponds to δ and ϵ Sagittarii.

22. *Uttara-Āṣāḍha*, the twenty-first *nakṣatra*, is represented by a couch or by an elephant's tooth. The principal or the most northerly star is placed in 5° S and 260° or 261° E, agreeing with a star in the body of Sagittarius (τ Sagittarii), and the other star is perhaps the one marked ζ . The Arabian lunar mansion corresponding to it is *Baldah*, consisting of six stars, two, of which are placed by Mohammad of Tizīn in declination 21° and 16° . One of these must be a star in the head of Sagittarius. Some authors, on the contrary, describe the lunar mansion as destitute of stars. Here the Arabs and Hindus do not show reconciliation.

22. *Abhijit*, the twenty-second asterism, consists of three stars figuring as a triangle or as a nut of floating Trapa (in modern Indian astronomy, it does not occupy an equal portion of the ecliptic with other *nakṣatras*). Its brightest star is very remote from the zodiac, being in 60° or 62° N. The longitude of its circle of declination is 265° , $266^{\circ} 40'$ or 268° according to different authorities. The corresponding lunar mansion of Arabs is *Zābih*, consisting of two stars (according to some, four) in the horns of Capricorn. This totally disagrees with Indian asterism.

20. *Śravaṇa*, the twenty-third *nakṣatra*, is represented by three footsteps, and contains three stars of which the middlemost is placed in 30° N (all authorities agree), and longitude 280° (*Sūrya-Siddhānta*) or 278° (Brahmagupta and *Śiromaṇi*), or 275° (*Grahalāghava*). The assigned latitude indicates the bright star in the Eagle, whence the three may be inferred to be α , β

and γ Aquilae. According to Arabs, the twenty-third lunar mansion is *Balā*, which consists of two stars in the left hand of Aquarius. Here again Arabian and Hindu divisions are at variance.

24. *Dhaniṣṭhā*, the twenty-fourth *nakṣatra*, is represented by a drum or tabor. It comprises four stars, the westernmost of which is placed in 36° N and according to Brahmagupta, *Sīromani* and the *Sūrya-Siddhānta* in 290° E (*Grahalāghava* gives 286°). This longitude of the circle of declination and the distance of the star on it from the ecliptic indicate the Dolphin : and the four stars are α , β , γ and δ Dolphini. The corresponding lunar mansion of Arabs is *Saud*, which comprises two stars in Aquarius (β and ζ Aquarii). Here again the two divisions disagree completely.

24. *Satahbīṣak*, the twenty fifth *nakṣatra*, is a cluster of 100 stars figured by a circle. The principal or the brightest has no latitude; or only a third, or at utmost half, a degree of south latitude; and longitude 320° . This best corresponds with λ Aquarii. According to Arabs, the twenty-fifth lunar mansion is known as *Akhbiyah* which consists of three stars only, placed in the wrist of the right hand of Aquarius. However, it appears from Ulugh Beg's tables, as well as from Mohammad of Tizīn's, that four stars are assigned to this mansion. The Indian and Arabian systems of division differ considerably but less widely according to some.

26. *Pūrva-Bhādrapada*, the twenty-sixth *nakṣatra*, consists of two stars represented by a couch or bed, or else by a double headed figure, one of which is placed in 24° N and 325° or 326° E. The only conspicuous star nearly in that position is the bright star in Pegasus (α Pegasi) and the other may be the nearest considerable star in the same constellation (ζ Pegasi). The twenty-sixth Arabian lunar mansion is *Mukaddim*, consisting of two brightest stars in Pegasus (α and β). Here the Indian and Arabian divisions show concurrence.

27. *Uttar-Bhādrapada*, the twenty-seventh *nakṣatra*, consists of two stars, figured as a twin or a person with double face, or else as a couch. The position of the most northerly of the two

is in 26° or 27° N and 337° E. which probably indicates the bright star in the head of Andromeda, and the other star to be the one in the extremity of the wing of Pegasus (γ Pegasi). This exactly agrees with the twenty-seventh lunar mansion of Arabs named as *Muakkher*. Ulugh Beg assigns those stars to it.

28. *Revati*, the twenty-eighth *nakṣatra*, comprises thirty-two stars figured as a tabor. The principal star is the southernmost one, it has no latitude, and two of them assert no longitude, but some make it ten minutes short of the origin of the ecliptic, viz. $359^{\circ} 50'$. This clearly marks the star on the ecliptic in the string of the Fishes (ζ Piscium). The ascertainment of this star is important in regard to the adjustment of the Hindu sphere. The Arabic name for this mansion is *Risha*, signifying a cord. But the constellation as described by Jauhari and cited by Golius, consists of a multitude of stars in the shape of a fish and termed *Betnu'lhūt*; in the navel of which is the lunar mansion. Mohammad of Tizin also makes this lunar mansion to be the same with *Betnu'lhūt*, which appears, however, to be the bright star in the girdle of Andromeda (β Andromedae) though others describe it as the northern fish, extending, however, to the horns of Ram. The lunar mansion and the Indian asterism, therefore, are not reconcileable in this last instance.

I leave it to the readers to draw an inference as to the concurrence of the divisions of zodiac in Indian and Arabian systems. I would personally agree with Sir William Jones that the agreements are by chance. Arabs derived the idea of dividing zodiac in 27 or 28 mansions from Indians, or may have got it from Greeks, and then they proceeded in their own way for details. I do not agree with those scholars who sometimes state that the Hindus took the hint of dividing the ecliptic from Greeks. The *Atharvaveda* devotes a number of Sūktas or hymns on Nakṣatras, and I have shown elsewhere that inspired by these hymns, Gārgya was the first Ṛṣi who detailed out the *nakṣatras*. This happened much before Greeks developed even their first notions of astronomy. While the concept of 27 *nakṣatras* is Vedic and most ancient and of purely Indian origin the concept of 12 Rāśis (signs) or twelve constellations is probably inspired from Greeks. [The names Kanyā, (virgo), Tula

(Libra), Vṛścika (Scorpio), Dhanu, (Sagittarius), Makara, (Capricorn), Kumbha (Aquarius), Mīna (pisces), Meṣa (Aries), Vṛṣa (Taurus), Mithuna (Gemini), Karka (Cancer), and Siṁha (Leo) were not used for Rāśis or signs in the Vedic times]. I shall conclude this description with a passage from Colebrooke :

The result of comparison shows, I hope satisfactorily, that the Indian asterisms, which mark the divisions of the ecliptic, generally consist of nearly the same stars, which constitute the lunar mansions of the Arabians : but in a few instances, they essentially differ. The Hindus have likewise adopted the division of the ecliptic and zodiac into twelve signs or constellations, agreeing in figure and designation with those of the Greeks; and differing merely in the place of the constellations, which are carried on the Indian sphere a few degrees further west than on the Grecian. That the Hindus took the hint of this mode of dividing the ecliptic from the Greeks, is not perhaps altogether improbable; but if such be the origin of it they have not implicitly received the arrangement suggested to them, but have reconciled and adapted it to their own ancient distribution of the ecliptic into twenty-seven parts.

In like manner, they may have either received or given the hint of an armillary sphere as an instrument for astronomical observation ; but certainly they have not copied the instrument which was described by Ptolemy, for the construction differs considerably.

Names, Shapes, and Number of the Stars of the Nakṣatras

The *Muhūrta-cintāmaṇi* provides a list of shapes associated to the nakṣatras (*MuC.* II. 59-60). In this list we are giving the number of stars as indicated by Varāhamihira, Brahmagupta and Lalla. The identification given here is as indicated by E. Burgess, in his Translation of the *Sūrya-Siddhānta* 1935, p. 378. (Calcutta). This table has been reproduced here from the *Mahābhāskariya* of Bhāskara I, edited by K.S. Shukla.

Nakṣatra	Shape	Number of stars			Identification
		Varāha	Brahma	Lalla	
Aśvinī	Head of a horse	3	2	3	α, β, γ Aries
Bharaṇī	Yoni	3	3	3	35, 39, 41 Aries
Kṛttikā	Razor	6	6	6	η Tauri etc. (Pleiades)
Rohiṇī	Cart	5	5	5	$\alpha, \theta, \gamma, \delta, \epsilon$ Tauri (Hyades)
Mṛgaśīrā	Head of a deer	3	3	3	λ, ϕ_1, ϕ_2 Orionis
Ārdrā	Jewel	1	1	1	α Crionis
Punarvasu	House	5	2	4	$\beta, \alpha, \iota, \nu, \mu$ Geminorum
Puṣya	Arrow-head	3	1	3	θ, δ, γ Cancri
Āśleṣā	Wheel	6	6	5	$\epsilon, \delta, \sigma, \eta, \rho$ Hydrae
Maghā	House	5	6	5	$\alpha, \eta, \epsilon, \zeta, \eta, \epsilon$ Leonis
P-Phalguni	Mañca	8	2	2	δ, θ Leonis
U-Phalguni	Cot	2	2	2	β , 93 Leonis
Hasta	Hand	5	5	5	$\delta, \gamma, \epsilon, \alpha, \beta$ corvi
Citrā	Pearl	1	1	1	α Virginis (Spica)
Svātī	Coral bead	1	1	1	α Bootis (Arcturus)
Viśakha	Arched doorway	5	2	4	$\iota, \gamma, \beta, \alpha$, Librae
Anurādhā	Heaps of offerings to gods	4	4	4	δ, β, π Scorpionis
Jyēṣṭhā	Earpendent	3	3	3	τ, σ, τ Scorpionis
Mula	Tail of a lion	11	2	11	$\lambda, \nu, \kappa, \iota, \theta, \eta, \zeta, \mu, \epsilon$ Scorpionis
P-Āṣāḍha	Tusk of elephant	2	4	2	δ, ϵ Sagittarii
U-Āṣāḍha	Mañca	3	4	2	σ, ξ Sagittarii
Śravaṇa	Three feet	3	3	3	α, β, γ Aquilae
Dhaniaṣṭh	Drum	5	5	4	$\beta, \alpha, \gamma, \delta$ Delphini
Satabhiṣak	Circle	100	1	100	λ Aquarii etc.
P-Bhādra	Mañca	2	2	2	α, β Pegasi
U-Bhādra	Pair	8	2	2	γ Pegasi; α Andromedae
Revati	Drum	32	1	32	ζ Piscium etc.

Reference

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CHAPTER XI

Brahmagupta's Astronomy : Its Highlights

Beginning or Starting Point

Very often in Indian astronomy, we come across a term *ahargana* (literally meaning collection of days), which means the number of mean civil days elapsed at mean Sunrise at *Laṅkā* on a given lunar day (*tithi*), since the beginning of *Kaliyuga*. It is the beginning of *Kaliyuga*, which is taken as the starting point for the reckoning of *ahargana*. This happened on Friday, February 18, B.C. 3102, at mean sunrise at *Laṅkā*, when the Sun, Moon, and the planets are supposed to have been in conjunction at the first point of the *nakṣatra* *Āśvinī* (which is a fixed point situated near the star ζ-Piscium). According to Āryabhaṭa and Bhāskara I, the duration of *Kaliyuga* is 1,080,000 solar years. Four times this (4,320,000) is the duration in solar years of a bigger unit called *Mahāyuga* or even *yuga*.

Laṅkā in Indian astronomy is a hypothetical place where the meridian of Ujjain (latitude 23° 11' N, longitude 75° 52' E from Greenwich) intersects the equator. It is one of the four hypothetical cities on the equator called *Laṅkā*, *Romaka*, *Siddhapur* and *Yamakoṭī* (or *Yavakoṭī*). The *Sūrya-siddhanta* describes *Laṅkā* as a great city (*mahāpurī*) situated on an island to the south of *Bhāratavarṣa*.¹ The present Ceylon is not the

1. समन्तान्मेरुमध्यात् तुल्यभागेषु तोययेः ।
द्वीपेषु दिक्षु पूर्वादिनगर्यो देवनिर्मिताः ॥
भूवृत्त पादे पूर्वस्यां यवकोटीति विश्रुता ।
भद्राश्व वर्षे नगरी स्वर्णप्राकारतोरणा ।
याम्यायां भारतेवर्षे लङ्का तद्दन्महापुरी ॥

astronomical Lankā, as it is about six degrees to the north of equator. The astronomical Lankā is mentioned by Brahmagupta in the beginning of his very first Chapter¹.

According to Brahmagupta all the four yugas of a *Catur-yuga* or *mahāyuga* are not of the equal duration :

Kaliyuga is of 432,000 years. *Dvāpara* of 864,000 years, *Tretā* of 1,296,000 years and *Kṛtayuga* of 1,728,000 years; total of the four is 4,320,000 years. Āryabhaṭa regards all *yugas* of equal duration, 1,080,000 years².

The Saka era, which is usually used in Indian astronomy for the reckoning of years commenced 3179 years after the beginning of *Kaliyuga*.

The number of lunar months in a *yuga* does not coincide with the number of solar months. Thus we have the conception of the *Intercalary months* : the number of intercalary months in a *yuga* denotes the excess of the number of lunar months in a *yuga* over the number of solar months in a *yuga*. Thus in a *yuga* we have

Lunar months	53,433,336
Solar months	51,840,000
Intercalary months	1,593,336
Lunar days	1,603,000,080
Civil days	1,577,917,500
Omitted lunar days	25,082,580

The number of omitted lunar days in a *yuga* is equal to the number of lunar days in a *yuga* minus the number of civil days in a *yuga*,

(Cont. from page 289)

पश्चिमेकेतुमालाख्ये रोमकाल्या प्रकीर्तिता ।

उदन्तिसद्धुरी नाम कुरुवै प्रतिष्ठिता ॥

—*Sūrya*. XII. 36-39

1. चैत्रसितादेरुद्याद्भानोर्दिनमासवर्षयुगकल्पाः ।

सृष्ट्यादौ लंकार्यां समं प्रवृत्ता दिनेऽर्कस्य ॥

—*BrSpSi*. I. 4

2. युगदशभागो गुणितः कृतं चतुर्भिस्त्रिभिर्गुणस्वेता ।

द्विगुणो द्वापरमेकेन संगुणः कलियुगं भवति ॥

युगपादानार्यभट्टश्चरि समानि कृतयुगादीनि ।

अद्विहितवान् न तेषां स्मृत्युक्तसमानमेकमपि ॥

—*BrSpSi*. I. 8-9

Units of time

For the measurements of durations, it is necessary to have units of time. Brahmagupta gives the following units :¹

6 prāṇas or Asus=1 Rkṣa-vināḍikā or nakṣatra-vighaṭikā
or one *pala* (24 seconds)

60 palas =1 ghatikā (24 minutes)

60 ghaṭikās =1 divasa or dina (day) (24 hours)

30 dinas =1 māsa (month)

12 māsas =1 varṣa or year

Similar to the divisions of time, we have the divisions of an arc :²

Vikalā (or viliptā or viliptikā) =second of arc.

60 vikalās =1 kalā (minute of arc)

60 kalās =1 aṁśa (degree of arc)

30 aṁśas =1 rāśi

12 rāśis =1 bhagaṇa (complete circle, 360°)

Unlike Āryabhaṭa and others, who take kali, dvāpara, tretā, and kṛta of equal number of years, Brahmagupta regards kali consisting of 432,000 years, dvāpara twice of it, consisting of 864,000 years, tretā thrice of Kali consisting of 1,296,000 years and kṛta four times of kali consisting of thus 1,728,000 years, all the four to be making a *yuga* of 4,320,000 years.³ Further in the beginning of kṛta there is a *sandhyā* of 1728000/12 years (=144,000 years), and at the end of Kṛta, there is a *sandhyā* of 144,000 years; similarly in the beginning of tretā, we have a

1. प्राणैर्विनाडिकाक्षीं षडभिर्वटिका षष्ठ्या ।

षटिका षष्ठ्या दिवसो दिवसानां त्रिंशत् मासाः ॥

—BrSpSi. I. 6

2. मासा द्वादशवर्षं विकलालिप्तांशराशिभगणांतः ।

क्षेत्र विभागस्तुल्यः कालेन विनाडिकाद्येन ॥

—BrSpSi. I. 6

वर्षं द्वादश मासास्त्रिंशदिवसो भवेत्समासस्तु ।

षष्टिर्नाड्यो दिवसषष्टिस्तु विनाडिका नाडी ॥

—Ārya. III. 1

गुर्दक्षराणि षष्टिर्विनाडिकाक्षीं षडेव वा प्राणाः ।

एवं काल विभागः क्षेत्र विभागस्तथा भगणात् ॥

—Ārya, III. 2

3. स्वचतुष्टयरदवेदा रवि वर्षाणां चतुयुगं भवति ।

सन्ध्या सन्ध्यतांशैः सह चत्वारि पृथक् कृतादीनि ॥

युगदशभागो युष्मिन् कृतं चतुर्भिस्त्रिभिर्गुणस्त्रेता ।

द्विगुणो द्वापरमेकेन संगुणः कलियुगं भवति ॥

—BrSpSi. I. 7. 8

sandhyā of 1,296,000/12; i. e. 108,000 years and at the close of tretā a sandhyāmsā of 108,000 years. Again, in the beginning of dvāpara we have a sandhyā of 864,000/12, i. e. 72,000 years and at the close of dvāpara a sandhyāmsā of 72,000 years; and similarly at the beginning a sandhyā and at the close a sandhyāmsā of 432,000/1, i. e. of 36,000 years in the case of kali. In this respect Brahmagupta appears to follow Manu, the first author or giver of law. He regards further the following divisions of time :¹

71 yugas = 1 manu

14 manus = 1 kalpa

Again, in the beginning, at the middle and at the close of each manu, there are sandhis, each equal to the measure of kṛta. Thus, taken as a whole

$$\begin{aligned} 1 \text{ kalpa} &= 71 \times 14 \text{ yugas} + 15 \text{ sandhyā-sandhyāmsā} \\ &= 994 \text{ yugas} + 15 \times \text{duration of kṛta} \\ &= 994 \text{ yugas} + 15 \times (4 \times 432,000) \text{ years} \\ &= 994 \text{ yugas} + 6 \text{ yugas} = 1000 \text{ yugas} \\ &= 1 \text{ Brahma-dīna (Brahmā's day)} \end{aligned}$$

Thus Brahmā's day is regarded as 1 kalpa or one thousand caturyugis or 1000 yugas or the same as 1000 mahāyugas).

Āryabhaṭa regards a manu to consist of 72 yugas and therefore a kalpa according to him would be of 14×72 yugas, or 1008 yugas.² Since in the foreign Siddhāntas like Romaka, there is no reference to yuga, manu and kalpa, Brahmagupta regards these systems to be unauthoritative.³

We have said that our starting point was the beginning of Kaliyuga. Friday February 18, B.C. 3102, at mean rise at Lankā, when the Sun, Moon and the planets are supposed to have been in conjunction at the first point of the Nakṣatra Aśvini. This type of conjunction would again happen after a period of kalpa.

1. मनुरेकसप्ततियुगः कल्पो मनवश्चतुर्दश मनुनाम् ।

आद्यन्तरान्त सन्धिषु कृतकालोऽस्माद्युग सहस्रम् ॥

—BrSpSi. I. 10

2. दिव्यं वर्षं सहस्रम् ग्रहसामान्यं युगं द्विषद्वक् गुणम् ।

अष्टोत्तरसहस्रं ब्राह्मो दिवसो ग्रहयुगानाम् ॥

—Ārya. III. 8

3. कुमन्वन्तरकल्पाः कालपरिच्छेदकाः स्मृतावुक्ताः ।

अस्मान्नेमेके ते स्मृतिबाह्ये रोमकस्तस्मात् ॥

—BrSpSi. I-13

We shall have the same type of conjunction of *grahocca*, *mandocca* *śighrocca* and *pāta* after a complete cycle of kalpa as we had in the beginning of creation. This is a natural observable cycle which is recognised in Indian astronomy and in no other foreign system; and hence only the Indian system recognises the time measure of *kalpa*.

Ucca or apex is of two kinds: *mandocca* (apex of the slowest motion) and *śighrocca* (apex of the fastest motion). The *mandocca* is that point of a planet's orbit which is at the remotest distance and where the motion of the planet is slowest. In the case of the Sun and the Moon, it is the apogee; and in the case of other planets, it is the apogee or aphelion, the geocentric longitude of the apogee being equal to the helio-centric longitude of the aphelion. The *śighrocca* of a superior planet (Mars, Jupiter and Saturn) is defined as the mean Sun; that of an inferior planet Mercury or Venus) *śighrocca* is an imaginary body which is supposed to move in such a way that its direction from the earth is always approximately the same as that of the actual planet from the Sun.

The *bhagaṇas* or the revolution numbers of a planet have been given by Āryabhaṭa and Brahmagupta¹ both; they mean the number of revolutions that a planet performs in a certain period, say a kalpa of 4,320,000,000 years.

The *bhagaṇas* of planets are given as follows :

1. कल्पेऽर्कबुधसितानां भगणाः शून्यानि सप्त रदवेदाः ।
 प्राग्भ्रजता कुजगुरुशनि शीघ्रोच्चानां स्वकक्षासु ॥
 पञ्चान्वराणि गुह्य-गुह्या पञ्चमुनि स्वशरैर्मिताः शशिनः ।
 भौमस्य द्वियमशराष्टपक्षवसुरत्ननवद्वियमाः ॥
 कृतवसुनवाष्टनद-नवषट्त्रि नवागेन्द्रबोद्धरीध्रस्य ।
 जीवस्य शरेषूदधि षट्पक्षद्वि कृतरसरामाः ॥
 सितरीध्रस्य यमलगोवेदनवाष्टानिपक्षयमखनगाः ।
 अष्टनवपक्ष मुनि रत्नशररत्न मनवोऽर्कपुत्रस्य ॥
 खाष्टान्वयो क्सुशरवसुपञ्चखचन्द्रकसुवसुसमुद्राः ।
 दिनवयमा द्वित्रिगुह्याः शरेषु वसवस्त्रि पञ्चरसाः ॥
 शशिवेदा मन्दानामर्कादीनां विलोमपातानाम् ।
 वसुरत्नरुद्रेन्दुगुह्या द्विनियमाः सप्तरसपक्षाः ॥
 शशियमशरा गुह्यारसास्त्रिनन्दवसवः समुद्रवसु विषयाः ।
 चन्द्रादीनां पञ्चान् ब्रजतोऽश्विन्यादि भगणस्य ॥

Planet or a body	Bhagaṇas
Ravi or Sun	4,320,000,000
Budha or Mercury	4,320,000,000
Śukra or Venus	4,320,000,000
Candra or Moon	57,753,300,000
Kuja or Bhauma or Mars	2,296,828,522
Budha-śighrocca	17,936,998,984
Bṛhaspati or Jupiter	364,226,455
Śukra-śighrocca	7,022,389,492
Śani or Saturn	146,567,298
Arka or Ravi-mandocca	480
Candra mandocca	488,105,858
Kuja or Bhauma mandocca	292
Budha-mandocca	332
Bṛhaspati or Jīva-mandocca	855
Śukra-mandocca	653
Śani-mandocca	41
Candra-pāta	232,311,168
Kuja or Bhauma-pāta	267
Budha-pāta	521
Bṛhaspati or Guru-pāta	63
Śukra-pāta	893
Śani-pāta	584

By pāta is meant the ascending node of a planet's orbit (on the ecliptic).

In a kalpa, the number of *bha-bhramas* (sidereal days) or also known as *bha-parivartas* is 51,040,000,000. If we subtract out from this number the *bhagaṇa* of the Sun, we get what is known as *ku-dinas* or *Savana* days or the solar or sacrificial days. $(51,040,000,000 - 4,320,000,000 = 46,720,000,000)$ *Savana* days or *kudinas*).

In a kalpa, the number of Ravi-bhagaṇas also correspond to the number of solar years (*Saura-varṣas*). i.e., 4,320,000,000; this number multiplied by 12 gives the number (i.e. 51,840,000,000) of solar months.

The difference between the candra-bhagaṇas and the Ravi-bhagaṇas in a kalpa gives the number of lunar months (*Candra-*

māsa) in a kalpa (57,753,300,000-4,320,000,000=53,433,300,000 lunar months).

By subtracting the number of solar months from the number of lunar months in a kalpa, one gets the number of *adhi-māsas* (additional-months) : 53,433,300,000-51,840,000,000=1,593,300,000 *adhi-māsas*. This multiplied by 30 gives the number of lunar days (śaśi-divasa) in a kalpa ; 53,433,300,000×30=1,602,999,000,000 lunar days. The difference between the lunar days and *kudinaṣ* in a kalpa gives the number of *avama-dinas* in a kalpa : 1,602,999,000,000-45,720,000,000=1,556,279,000,000.¹

Brahmagupta calculates out the *sṛṣṭi-samvatsara* or the Creation Era during his year of composition of the Treatise. He says : Six manus have gone in the kalpa ; the seventh manu is now running of which have lapsed 27 caturyugis ; of the twenty eighth caturyugī, the three yugas, *kṛta*, *dvāpara* and *tretā* have gone by and also of the present *kaliyuga* 3179 years have lapsed. The total period thus lapsed on calculation comes to be 1,972,947,179 years :²

$$\begin{aligned} \text{Total Period} &= 6 \text{ manus} + 7 \text{ manu} - \text{sandhis} + 27 \text{ yugas} \\ &+ \text{kṛta} + \text{dvāpara} + \text{tretā} + 3179 \text{ years of kali.} \\ &= (6 \times 71 \times 4,320,000 \text{ years}) + (7 \times 4 \times 432,000 \text{ years}) + \\ &(27 \times 4,320,000 \text{ years}) + (1,728,000 + 1,296,000 + 864,000) + \\ &3,179 = 1,972,947,179 \text{ years.} \\ &= 1,840,320,000 + 12,096,000 + 116,640,000 + 3,888,000 + \\ &3,179 = 1,972,947,179 \text{ years.} \end{aligned}$$

Calculation of Ahargana : The method of calculating *ahargana* (number of days elapsed since the beginning of *kaliyuga*)

1. परिवर्त्ताः स्वचतुष्टयः त्रावि रसगुण्यमद्विवसुतिथयः ।
रवि भग्याना भानोः सावनदिवसाः कुदिवसास्ते ॥
रवि भग्याख्यब्दा द्वादशगुणिता भवन्ति रविमासाः ।
भग्यान्तरं रवीन्द्रोः शशिमासाः सूर्यमासोनाः ॥
अभिमासाः शशिमासास्त्रिंशद्गुणिता भवन्ति शशिविदाः ।
शशिमासदिवसान्तरं नवमानि तिथिः शशांकदिनम् ॥

—BrSpSi. I. 22-24

2. कल्पपराद्धमनवः षट्कस्य गताश्चतुर्गुणत्रिघनाः ।
त्रीणि कृतादीनिकलेगोऽगैक गुण्याः शकान्तेऽब्दाः ॥
भवनगराशि मुनिकृत नव यमनगनन्देन्दवः शकनृपान्ते ।
सार्धमतीतमनूनां सन्धिमिराधनरान्तमैः ॥

BrSpSi. I. 26-27

has been given by Brahmagupta and Bhāskara I is almost identical. The rule given in the *Brahmasphuṭasiddhānta*¹ may be compared with the following given by Bhāskara I in the *Laghu-Bhāskariya*:

Add 3179 to the (number elapsed) years of the Śaka era. (then) multiply (the resulting sum) by 12, and (then) add the (number of lunar) months (expired) since the commencement of Caitra. Set down (the result thus obtained) at (two) separate places; multiply (one) by (the number of) intercalary months in a *yuga*, which are 1,593,336 in a *yuga* : and divide (the product) by $5,184 \times 10,000$ (i.e.) by 51,840,000). Add the (resulting complete) intercalary months to the result placed at the other place. Then multiply (that sum) by 30 and (to the product) add the (lunar) days (i.e. *tithis*) expired of the current month. Set down (the result thus obtained) in two places; multiply (one) by the (number of) omitted lunar days in a *yuga* i.e. by 25,082,580 and divide by 1,603,000,080. The resulting (complete) omitted lunar days when subtracted from the result put at the other place give the (required) *ahargana*. The remainder obtained on dividing (the *ahargana*) by 7 gives the day beginning with Friday at sunrise (at *Laṅkā*)²

1. कल्पगतान्द् द्वादशघातश्चैत्रादिमास युवतोऽयः ।

गुणितो युगाधिमासै रविमासाः ताधिमास युतः ॥

त्रिंशद् गुणास्तिथियुत्य पृथग् युगावमगुणो युगेन्दु दिनैः ।

भवतः फलावमोनोऽर्कं सावनाहर्गणोऽर्कादिः ॥

— *BrSpSi*. I. 29-30

2. नवाद्रयेकावित संयुक्ताः शकान्द्रा द्वादशहताः ।

चैत्रादिमास संयुक्ताः पृथग् गुण्या युगाधिकैः ॥

ते च षट् त्रिकरामाहित नव भूतेन्दवो युगे ।

भागहारोऽपि वस्त्येक शरास्युर युताहताः ॥

अधिमासाः पृथक्स्थेषु प्रक्षिप्य त्रिंशताहते ।

युत्तवादिनानि यातानि प्रतिराश्य युगावगैः ॥

संगुणव्या-बराष्टेषु द्रष्टृशून्यशराः शिवभिः ।

क्षेदः स्वप्नविष्यद् व्योमस्य खाग्नि खरसेन्दवः ॥

लब्धान्यवरराठाणि तेषु शुद्धेष्वहर्गणः ।

खरः सप्तहते शेषे शुक्रादिभस्कारोदयात् ।

— *LBh*. I. 4-8

Addendum : The mean lunar day (*madhyama tithi*) may, however, differ from a true lunar day (*spaṣṭa tithi*) by one, so that the *ahargana* obtained by the above process may sometimes be in excess or defect by one. To test whether the *ahargana* (obtained by the above process) is correct, it is divided by seven and the remainder counted with Friday. If this leads to the day of calculation, the *ahargana* is correct; if it leads to the preceding day, the *ahargana* is in defect; and if that leads to the succeeding day, the *ahargana* is in excess. When the *ahargana* is found to be in defect, it is increased by one; when it is found to be in excess, it is diminished by one. (K.S. Shukla : *MBh.* p. 4-5)

Example—Calculate the *ahargana* on October 1, 1965.

From Indian Calendar we find that October 1, 1965 falls on Friday. 7th lunar day (*tithi*) in the light half of the 7th month Āśvina in the Saka year 1887 (elapsed). Let us proceed as follows :

Adding 3,179 to 1,887. we get 5,066. (1)

Multiplying this by 12 and adding 6 (i. e. the number of lunar months elapsed since the beginning of Caitra) we get 60,798. ... (2).

Multiplying this by 1,593,336 and dividing the product by 51,840,000, we get 1,868 as quotient. (The remainder is discarded as unnecessary) (3)

Adding this number (i.e. 1,868) to the previous one (i.e.) 60,798 we get 62,666. (4)

Multiplying this by 30 and adding 6 (i.e. the number of lunar days elapsed since the beginning of the current month) to the product, we get 1,879,986. (5)

Multiplying this by 25,082,580 and dividing the product by 1,603,000,080, we get 29,416 as the quotient. (The remainder is discarded as not necessary). (6)

Subtracting this number (i.e. 29,416) from the previous one (i.e. 1,879,986) we get 1,850,570. (7)

This is the required *ahargana*. Since division by 7 leaves

1 as the remainder. we subtract one from it, and get 1,850,569 as the correct *ahargana* for the day.

An Alternative Rule for *Ahargana*

Both Bhāskara I and Brahmagupta give an alternative rule for calculating out *ahargana*¹ :

Multiply the number of (solar months) elapsed since the beginning of kaliyuga by the number of lunar months (in a *yuga*) and divide by the number of solar months (in a *yuga*). Reduce the quotient to days (and add the number of lunar days elapsed since the beginning of the current lunar month); then multiply by the number of civil days (in a *yuga*) and divide by the number of lunar days (in a *yuga*); the quotient denotes the *ahargana*.

Mean Longitude of a Planet

(i) The mean longitude of a planet in *revolutions* is given by the expression : (Brahmagupta² and also Bhāskara³).

1. शशांकमासैरभिताडितान् हरेदतीतमासानर्थवार्कसम्भवैः ।
दिनीकृतान् भूमिदिनैर्हृतान् दिनैर्विभज्य लब्धशशिशिजैरहर्गणः ॥ MBh. I. 7
युगगतशशिमासवधाद्रविमासाप्तं दिनीकृतं सदिनम् ।
भूदिनगुणितं शशिदिनहतमाप्तमहर्गणः सैकः ॥ —BrSpSi. XIII. 18
2. इष्टग्रह भगण गुणादहर्गणात् कल्पसावन धु हुतात् ।
भगणादि फलं मध्यो लंकायां भास्करौदयिकः ॥ BrSpSi. I. 31
3. उदादितान् यान् भगणान् क्षमादिनैर्लभामहे कान् कलियातवासरैः ।
इति प्रलब्धा भगणास्ततः क्रमाद् गुहांशलिप्ता विकलाः सततपराः । —MBh. I. 8
पर्ययाहर्गणाम्यासो ह्यपि ते भूदिनैस्ततः ।
लभ्य ते पर्ययाः शेषाद्राशि भागकलादयः ॥
भास्करैस्त्रिंशता षष्ट्या सङ् गुण्य पृथक् पृथक् ।
तेनैव भागद्वारेण लभ्यन्तेऽर्कोदयावधेः ॥ —LBh. I. 15-17

(Divide the product of the revolution-number of a planet and the *ahargana* by the (number of) civil days (in a *yuga*); thus are obtained the (number of) revolutions (performed by that planet). From the (successive remainders multiplied respectively by 12,30 and 60 and divided by the same divisor (i.e. the number of civil days in *yuga*) are obtained the signs, degrees and minutes etc. (of the mean longitude of that planet) for (mean) sunrise (at Lanka).

$$\text{Mean longitude} = \frac{\text{revolution number of planet} \times \text{ahargana}}{\text{civil days in a yuga}}$$

Similar expression is given by more recent Indian astronomers also.

(ii) Mean longitude of desired planets in minutes

$$\begin{aligned} & (\text{mean longitude of the known planet in revolutions etc. reduced to minutes}) \times (\text{revolution number} \\ & \quad \text{of the desired planet}) \\ & = \frac{\quad}{\text{revolution number of the known planet.}} \end{aligned}$$

This rule is common to Brahmagupta¹ and Bhāskara I².

(iii) An alternative rule for deriving the mean longitude of the Moon from that of the Sun and vice versa has been given by Bhāskara I and Brahmagupta both.

Multiply the *ahargana* by the number of intercalary months in a *yuga* and divide (the product) by the number of civil days (in a *yuga*): the result is in the terms of revolutions etc. Add that to thirteen times the mean longitude of the Sun. (This is the process) to obtain the mean longitude of the Moon³.

Mean longitude of the Moon

$$= \frac{(\text{intercalary months in a yuga}) \times \text{ahargana}}{\text{civil days in a yuga}} \text{ revolutions}$$

1. ज्ञातभगणादिभुक्तं सविकलमिष्टयुग भगणसंगुणितम् ।

ज्ञात युगभगणभक्तं मध्यो भगणादि फलमिष्टः ॥

—BrSpSi. XIII. 27

2. निशाकरं वायव्यमुच्चमेव वा कर्लाकृतं तत्सह्युतमण्डलैः ।

यथेष्ट नक्षत्रगणैर्दत्तं हरेत् तदीयनक्षत्र गणैस्ततः कला ॥

MBh. I. 10

The (mean) longitude of the Moon, the planet, or the *Ucca* (whichever is known) together with the revolutions performed should be reduced to minutes. The resulting minutes should then be multiplied by the revolution-number of the desired planet and (the product obtained should be) divided by the revolution-number of that (known) planet. The result is (the mean longitude of the desired planet) in minutes.

3. द्युगणं युगाधिसासैर्गुणितं युग भूदिनैर्भजेल्लब्धम् ।

भगणादि मध्यमार्के त्रयोदश गुणाधिकं चन्द्रः ॥

—BrSpSi. XIII. 33

युगाधिसासैर्द्युगणं हतं हरेत् क्षमादिनैर्वा भगणादि लभ्यते ।

त्रयोदशध्वे सवितर्यथा क्षिपेन्निशीथिनीनां पतिचारसिद्धये ॥

—MBh. I. 11

+13 (Sun's mean longitude)

This expression may be rearranged to get the mean longitude of the Sun from the mean longitude of the Moon¹.

Mean longitude of the Sun

$$= \frac{1}{13} [\text{mean longitude of the Moon} \\ - \frac{(\text{intercalary months in a yuga}) \times \text{ahargana}}{\text{civil days in a yuga}} \text{ revolutions}]$$

**Calculating the Mean
Longitudes of the Sun and
the Moon without using Ahargana**

Bhāskara I follows the method of Āryabhaṭa I and the same method more or less has been adopted by Brahmagupta in calculating the mean longitudes of the Moon and the Sun without the use of *ahargana*. The method may be described thus :

Reduce the years elapsed since the beginning of kali-yuga to months and add to them elapsed months of the current year. Then multiply the sum by 30 and add the product to the number of lunar days elapsed since the beginning of the current month. Multiply that sum by the number of intercalary months in a *yuga* and divide by the number of solar months in a *yuga* reduced to days; the quotient denotes the number of intercalary months elapsed. The remainder is the *adhimāsaśeṣa*. Multiply the complete intercalary months thus obtained by 30 and to the product add the number of solar days elapsed since the beginning of kaliyuga²; then multiply that sum by the number of omitted lunar days in a *yuga* and divide by the number of lunar days in a *yuga*; the remainder obtained is the *avamāśeṣa* called *āhnikā*. Then multiply the *avamāśeṣa*

1. कुसुमदीर्घा सुहृदोऽथवाऽऽगतं विरोधस्य शेषस्य लवस्त्रयोदशः ।

स मध्यमाको गणकैर्निरूप्यते गुरुप्रसादात्प्रति बुद्ध बुद्धिसिः ॥

MBh. I. 11-12

2. By the number of solar days here is meant the number obtained above by reducing the years elapsed since the beginning of kaliyuga to months, then adding to them the number of months elapsed since the beginning of the current year, then multiplying the sum by 30, and then adding to the product thus obtained the number of lunar days elapsed of the current month.

(also called *āhnika*) by the number of intercalary months in a *yuga* and divide by the number of civil days (in a *yuga*). Add the resulting quotient to the *adhimāsaśeṣa* and divide the sum by the number of lunar months in a *yuga* : this gives degrees etc. (This is the total *adhimāsaśeṣa*). Next multiply again the *avamaśeṣa* called *āhanika* by 60 and divide by the number of civil days in a *yuga* : the result is in minutes, seconds, thirds etc. The number of months elapsed (since the beginning of Caitra) are to be taken as signs and the number of lunar days elapsed of the current month as degrees. The sum of these signs and degrees and the minutes, seconds etc. corresponding to the *avamaśeṣa* is the *grahatanu*. From thirteen times and from one time that *grahatanu* severally subtract the degrees, minutes etc. corresponding to the total *adhimāsaśeṣa* : the remainders thus obtained are the mean longitudes of the Moon and the Sun respectively¹.

1. गुणिताद्युग्माधिसासैर्गुग्मदिवसैर्हृतादवमशेषात् ।

फलयुक्तमधिकमासकरोषं मध्यावतोऽकेन्द्र ॥

अधिसासावमशेषे युगशशि भूदिनहते पृथग्लब्धेः ।

मासदिनाद्ये स्थान्ये गतमासदिनानि चैत्रादेः ॥

अवमासशेषलब्ध्या सहितानि पृथक् त्रयोदश गुणानि ।

अधिसास शेषलब्ध्या हीनानि पृथक् रविशरांकौ ॥

—BrSpSi. XIII. 20-22

विनाद्युशशोरपि चन्द्रभास्करो प्रकुर्वतो वा विधिरेव न ध्येते ।

समाप्त्य मासीकृतविग्रहास्तु ये ह्यतीतमासा विनियोज्य तान् पुनः ॥

खरामनिघ्नान् दिवसेषु योजयेद् गतेषु मासस्य ततोऽधिमस्तकैः ।

निहत्य सर्वं विभजेत् सर्वदा युगाकमासैर्दिवसत्वभागजैः ॥

भवन्ति लब्धास्त्वधिसासकाः पुनस्ततोऽपनोयाशु च भागहारकम् ।

भजेत शेषं शशिसास संख्यया ततोऽशलिप्ता विकलाः स तत्पराः ॥

ततोऽधिसासान् प्रणिहत्य खान्तिभिर्नियोज्य सम्यग्गत्वासरैः क्रमात् ।

युगावमघ्नाञ्छशिवसुरैर्हरेत् तमत्र शेषं प्रवदन्ति चाहिकम् ॥

हत्वाऽधिसासैरवमस्य शेषं छित्वा धराया दिवसैः प्रलब्धम् ।

संयोज्य नित्यं त्वधिसासशेषे कार्यं पुनस्तत् करणैर्यथोक्तम् ॥

युगप्रसिद्धैर्धरणी दिनैर्हरेन्निहत्य षष्ठं यावमशेषमान्हिकम् ।

कलाविलिप्ताः क्रमशस्तत्परास्त्वतीतमासा दिवसा गुहांशकाः ॥

त्रयोदशान्नादपि रूपताडिताद्विशोधयेद्यत्वधिसासशेषजम् ।

निशाकराकौ गणकैः प्रकीर्तितौ भट प्रणीताविति बुद्धिमत्तमैः ।

—MBh. I. 13-19

(Here verse 17 should follow verse 15—K.S. Shukla)

K. S. Shukla has provided the following rationale to the rule cited above :

The fraction of the intercalary month (obtained in the rule) = $\frac{\text{adhimāsaśeṣa}}{\text{solar days in a } yuga}$, in mean lunar months.

$$= \frac{\text{adhimāsaśeṣa}}{\text{lunar days in a } yuga}, \text{ in mean solar months. (i)}$$

The fraction of the omitted lunar day (obtained in the rule)

$$= \frac{\text{avamaśeṣa or āhnikā}}{\text{lunar days in a } yuga}, \text{ in mean civil days.}$$

$$= \frac{\text{avamaśeṣa}}{\text{civil days in a } yuga}, \text{ in mean lunar days.}$$

$$= \frac{\text{avamaśeṣa} \times 60}{\text{civil days in a } yuga}, \text{ in mean lunar } ghaṭis. \text{ (ii)}$$

The fraction of the intercalary month corresponding to the above fraction of the omitted lunar day

$$= \frac{(\text{intercalary months in a } yuga) \times (\text{avamaśeṣa})}{(\text{lunar days in a } yuga) \times (\text{civil days in a } yuga)},$$

in mean solar months. (iii)

Adding (i) and (iii) and multiplying by 30, the total fraction of the intercalary month

$$= \left\{ \frac{\text{adhimāsaśeṣa}}{\text{lunar months in a } yuga} + \frac{(\text{intercalary months in a } yuga) \times (\text{avamaśeṣa})}{(\text{lunar months in a } yuga) \times (\text{civil days in a } yuga)} \right\}$$

in mean solar days. (iv)

Suppose that m lunar months and d lunar days have elapsed since the beginning of Caitra. Then, treating them as mean lunar months and mean lunar days, m months and d days denote the time elapsed since the beginning of mean Caitra up to the beginning of the current lunar day (treated as mean lunar day). As (ii) is the interval, in mean lunar *ghaṭis*, between the beginning of the current lunar day and the mean sunrise on that day, therefore

$$m \text{ months} + d \text{ days} + (\text{ii})$$

denotes the time in mean lunar months, days, *ghaṭis*¹ elapsed

1. 1 hour = 2½ *ghaṭis*; 1 *ghaṭi* = 60 *vighaṭis*; 1 *vighaṭi* = 60 *pravighaṭis*.

since the beginning of mean Caitra up to the mean sunrise on the current lunar day.

Like wise

$$m \text{ months} + d \text{ days} + (ii) - (iv)$$

denotes the time in mean solar months, days, ghaṭis etc. elapsed since the beginning of the current mean solar year up to the mean sunrise on the current lunar day¹.

Let M, D, G, V, and P denote respectively the mean solar months, mean solar days, mean solar ghaṭis mean solar vighaṭis and mean solar pravighaṭis elapsed since the beginning of the current mean solar year up to the mean sunrise on the current lunar day. Then evidently mean longitude of the Sun

$$= M \text{ signs, } D \text{ degrees, } G \text{ minutes, } V \text{ seconds and } P \text{ thirds.}$$

$$= (m \text{ signs and } d \text{ degrees}) + [\text{minutes, seconds etc. corresponding to (ii)}] - [\text{degrees, minutes etc. corresponding to (iv)}].$$

and mean longitude of the Moon

$$= 13 [m \text{ signs and } d \text{ degrees} + (\text{minutes, seconds, etc. corresponding to (ii)}) - (\text{degrees, minutes etc. corresponding to (iv)})]$$

because

$$[(1/12) \text{ mean longitude of the Moon} - \text{mean longitude of the Sun.}]$$

$$= m \text{ signs} + d \text{ degrees} + (\text{minutes, seconds etc. corresponding to (ii)})$$

(This equality is based on the fact that the left hand side denotes the mean lunar date also known as *madhyama tithi*).

A similar rule of these calculations of the mean longitude

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1. Because (iv) is equal to fraction of a lunar month between the beginning of Caitra and the beginning of the current mean solar year fraction of an intercalary month corresponding to the tithis elapsed up to the beginning of the current mean lunar day since the beginning of Caitra fraction of an intercalary month corresponding to the *avamaśeṣa*, i.e., the lunar portion between the beginning of the current lunar date and the following sunrise.

of the Sun and the Moon without basing on *ahargana* has also been given by Brahmagupta in the *Khaṇḍakhādya*¹.

Concordance of Working Rules

There has been a good deal of agreement on various rules of astronomical constants from the time of Āryabhaṭa I (499 A. D.) to the Bhāskara II (1150 A. D.) or even later to the days of Muṇiśvara (1620 A. D.). Earliest concepts were formulated during the days of the Vedāṅga-Jyautiṣa and the Siddhāntas of Indian and the western origin, for example of Brahma, Vasiṣṭha, Pitāmaha, Romaka and Puliśa. We in this section are giving some important concordances which we find common in the writings of Brahmagupta and his predecessors, contemporaries and successors as listed below. The list is not exhaustive. Only a few illustrations have been cited.

1. Ārya.—*Āryabhaṭīya*, Āryabhaṭa I, 499 A. D.
2. BrSpSi.—*Brahmasphuṭasiddhānta*, Brahmagupta, 628 A. D.
3. K. K.—*Khaṇḍakhādya*, Brahmagupta, 628 A. D.
4. KKu.—*Karṇa-kutūhala*, Bhāskara II, 1150 A. D.
5. LBh.—*Laghu-Bhāskariya*, Bhāskara I, 522 A. D.
MBh.—*Mahā-Bhāskariya*, Bhāskara I, 522 A. D.
MSi.—*Mahā-siddhānta*, Āryabhaṭa II, 950 A. D.
PSi.—*Pañcasiddhāntikā*, Varāhamihira, 505 A. D.
ŚiDVṛ.—*Śiṣyadhivṛddhida*, Lalla, 598 A. D.
SiSā.—*Siddhāntasārvabhauma*, Muṇiśvara, 1620 A. D.
SiSe.—*Siddhāntasekhara*, Śrīpati, 1039 A. D.
SiSi.—*Siddhānta-Siromaṇi*, Bhāskara II, 1150 A. D.
SuSi.—*Sūryasiddhānta*, Modern, 6th or 7th Century.

1. Rule for finding the mean longitudes of the Sun, Mercury and Venus : BrSpSi. I. 44.

Also MBh. 1. 31. MSi I. 26 ; SiSe II. 42, 43 ; SiSi. I i. (d). 15 ; SiSā I. 105 ; KKu I. 7.

2. Rule for finding the mean longitude of the Moon's ascending node : BrSpSi, XXV. 35.

1. दिनवत्सप्तमवमादशेषमाप्त दिनादि तत्सहितान् ।
अधिसासशेषकाच्च त्रिंशद् गुणितान्खदिग्भिः ॥
मासदिन प्रथमेक्यं पृथक् त्रयोदशगुणं द्वितीयोनौ ।
द्राक्ष्येवं मन्थौ रासयावत्कर्कचन्द्रौ वा ॥

=KK. I. 11-12

Also *MBh.* I. 33 ; *ŚiDVṛ.* I. i. 52 (ii)

3. Rule for finding the mean longitude of the *Śighrocca* of Venus and also giving the additives for the *Śighrocca* of Mercury and Moon : *BrSpSi.* XXV. 36.

Also *MBh.* I. 35 ; *ŚiDVṛ.* I. i. 57 (ii)

4. Rule for finding the mean longitude of the *Śighrocca* of Mercury : *BrSpSi.* XXV. 34.

Also *MBh.* I. 36 ; *ŚiDVṛ.* I. i. 50 (ii)

5. Rule for finding the mean longitude of Saturn : *BrSpSi.* XXV. 35.

Also *ŚiDVṛ.* I. i. 52 (i) ; *MBh.* I. 37.

6. Rule for finding the mean longitude of Mars : *BrSpSi.* XXV. 33.

Also *ŚiDVṛ.* I. i. 50 (i) *MBh.* I. 38.

7. Rule for finding the mean longitude of Jupiter : *BrSpSi.* XXX. 35.

Also *MBh.* I. 39 ; *ŚiDVṛ.* I. i. 51 (i).

8. Rule for finding the distance of a place from the prime meridian : *BrSpSi.* I. 36.

Also *MBh.* II. 3-4 ; *LBh.* I. 25-26 ; *ŚiDVṛ.* I. 57-58 (i) ; *SiŚa.* I. 143-144.

9. Rule for finding the directions : *BrSpSi.* III. 1.

Also *MBh.* III. 2 ; *SuSi.* III. 1-4 ; *LBh.* III. 1 ; *SiDVṛ.* I. iii. 1 ; *MSi.* IV. 1-2 ; *SiŚe.* IV. 1-3 ; *SiŚi.* I. iii. 8-9.

Alternative rule : *BrSpSi.* III. 2.

Also *MBh.* III. 3 ; *PSi.* XIV. 14-16 ; *ŚiDVṛ.* I. iii. 2 ; *SiŚe.* IV. 4.

10. Rule for finding the latitude and colatitude and the zenith distance and altitude of the Sun : *BrSpSi.* III. 10.

Also *MBh.* III. 5 ; *SuSi.* III. 13-14 ; *LBh.* III. 2-3 *ŚiDVṛ.* I. iii. 4-5 ; *SiŚe.* IV. 7 ; *SiŚi.* I. iii. 18.

11. Rule for determining the declination, day—radius, earth sine and ascensional difference (for the Sun or a point on the ecliptic) : *BrSpSi.* II. 55.

Also *SuSi.* II. 28 ; *LBh.* II. 16 ; I. ii *ŚiDVṛ.* 17 ; *SiŚe.* III.

63-64 ; *SiŚi*. I. ii. 47 (ii) (For RSine of the Declination).

BrSpSi. II. 56 ; also *Ārya*. IV 24 ; *MBh*. III, 6 ; *LBh*. II. 17 ; *ŚiDVṛ*. I. ii. 18 ; *SiŚe*. III. 66 ; *SiŚi* I. ii. 48 (For day-radius).

BrSpSi. II. 57-58 ; also *MBh*. III. 7 ; *LBh*. II. 18 ;

SuSi .II. 61; *ŚiDVṛ*. I. ii. 18 ; *SiŚe* III. 67 ; *SiŚi*. I. ii. 49 (i) (For the ascensional difference).

12. For finding the times of rising of the sāyana signs at the equator : *BrSpSi*. III. 15.

Also *MBh*. III. 9 ; *SuSi*. III. 42-43 : *ŚiDVṛ*. I. iii. 8 ; *SiŚe*. IV. 15 ; *SiŚi* I. 11. 51.

13. Rule for finding the ascensional differences of the Sāyana signs Aries, Taurus and Gemini : *KK*. 1. 21.

Also *MBh*. III. 8 ; *PSi*. III. 10 ; *ŚiDVṛ*. 1. XIII. 9 ; *SiŚi*. I. ii. 50-51.

14. Rule for the determination of the meridian zenith distance and meridian altitude of the Sun with the help of the Sun's declination and the latitude of the place ; *BrSpSi*. III. 47.

Also *MBh*. III. 11 ; *LBh*. III. 27 ; *ŚiDVṛ*. I. iii. 16 ; *SiŚe*. IV. 42.

15. Rule for determination of the latitude with the help of the Sun's meridian zenith distance and declination :

BrSpSi. : III. 13.

Also *MBh*. III. 17 ; *LBh*. III. 34 ; *SuSi*. III. 15-16 ; *SiŚe*. IV. 51,

16. Rule for finding out the Rsine of the Sun's altitude for the given time in *ghaṭis* : *BrSpSi*. III. 25-26 Also *Ārya* IV. 28 ; *MBh*. III. 18-20 ; *LBh*. III. 7-10 ; *ŚiDVṛ*. I. iii. 24-25 ; *SiŚe*. IV. 32,34 ; *SiŚi*. I. iii. 53-54.

17. Rule for finding out the Sun's altitude : $R \sin \alpha =$

$$\frac{M \times \text{day radius}}{R} \times \frac{\text{gnomon}}{\text{hypotenuse of equinoctial midday shadow}}$$

where $M = R \sin (\text{given } ghaṭis \mp \text{asc. diff.}) R \sin (\text{asc. diff.})$, the upper or lower sign being taken according as the Sun is the northern or southern hemisphere, α is the Sun's altitude. *BrSpSi*. III. 27 (i).

Also *MBh.* III 24; *ŚiDVṛ.* I. iii. 27; *SiŚe* IV. 37

18. Rule for finding the Sun's altitude when the Sun's ascensional difference is greater than the given time : *BrSpSi.* III. 33 :

Also *MBh.* III 25, *LBh.* III. 11; *ŚiDVṛ.* I. iii. 29 *SiŚe.* IV. 41.

19. Rule for finding the Sun's altitude in the night : *BrSpSi.* III. 63.

Also *MBh.* III. 26; *LBh.* III. 11; *SiŚe.* IV. 89.

The Sun's altitude for the night has been called *Patāla Śanku* by Brahmagupta (*BrSpSi.* XV.9)

20. Rule for finding the longitude of the rising point of the ecliptic with the help of (i) the instantaneous *sāyana* longitude of the Sun and (ii) the civil time measured since sunrise, or with the help of (i) the Sun's *sāyana* longitude at sunrise and (ii) the sidereal time elapsed since sunrise : *BrSpSi* III. 18-20.

Also *MBh.* III. 30-32; *LBh.* III. 17-19; *SūSi.* III. 46-48;

ŚiDVṛ. I. iii. 11-12; *SiŚe* IV. 18-19 (i) : *SiŚi* I. iii. 2-4.

21. Rule for obtaining the civil time measured since sunrise with the help of (i) the Sun's instantaneous *sāyana* longitude and (ii) the *sāyana* longitude of the rising point of the ecliptic, or the sidereal time elapsed since sunrise with the help of (i) the Sun's *sāyana* longitude at sunrise and (ii) the *sāyana* longitude of the rising point of the ecliptic : *BrSpSi* III. 21-23.

Also *SūSi.* III.50-51; *MBh.* III. 34-36; *LBh.* III. 20;

ŚiDVṛ. I. iii. 13; *SiŚe* IV. 19 (ii)—22 (i); *SiŚi* I. iii. 5-7. (i).

22. Rule for determining the R Sines of the Sun's prime vertical altitude : *BrSpSi* III. 52.

Also *Ārya.* IV; *MBh.* III.37-38; *LBh.* III. 52.

(An error created by *Āryabhata* has been criticised by Brahmagupta.)

23. Construction of the locus of the end of the shadow of a gnomon : *BrSpSi.* III. 2-3.

Also *MBh.* III 52; *ŚiDVṛ.* I. iii. 3; *SiŚe.* IV. 5;

24. Rule for finding the Sun's mean anomaly : *BrSpSi.* II. 12 (i).

Also *MBh.* IV. 1; *SuSi.* II. 29; *ŚiDVṛ.* I. ii. 10; *SiŚe.* iii. 12; *SiŚi.* I. ii. 18-19 (i).

25. Rule for finding the RSine (Reversed sine) of an arc ($<90^\circ$): *BrSpSi.* II. 10.

Also *SuSi.* II. 31-32; *MBh.* IV. 3-14; *LBh.* II, 2 (11)-3 (i); *ŚiDVṛ.* I. ii. 12; *SiŚe.* III. 15; *SiŚi.* I. ii. 10 (ii)-11.

(We shall discuss it separately in the light of Brahmagupta formula.)

26. Rule for finding the Sun's equation of the centre: *BrSpSi.* II. 15 (ii);

Also *MBh.* IV. 4 (ii); . III *SiŚe.* 27

27. Rule for determining the Sun's true longitude: *BrSpSi.* XIV. 17-18.

Also *MBh.* IV. 21-23; *SiŚe.* III. 52.

28. Rule for finding the Sun's *bhujāntara* correction under the eccentric theory : *BrSpSi.* XIV. 19.

Also *MBh.* IV. 24.

29. Rule for determining the *cara-saṃskāra* or *cara* correction : *KK.* I. 22.

30. Rule for finding the semi-durations of the day and night : *BrSpSi.* II. 60; *KK.* I. 23.

Also *SuSi.* II. 62-63; *ŚiDVṛ.* I. ii. 20-21; *SiŚe.* III. 70; *SiŚi.* I. ii. 52.

31. Rule for calculating the *tithi* : *BrSpSi.* II. 62; *KK.* I. 25.

Also *SuSi.* II. 66; *ŚiDVṛ.* I. ii. 22; *SiŚe.* III. 71; *SiŚi.* I. ii. 66.

32. Rule for calculating the *Karāṇa* : *KK.* I. 27.

Also. *ŚiDVṛ.* I. ii. 24; *SiŚe.* III. 77; *SiŚi.* I. ii. 66.

33. Rule for calculating *nakṣatra* : *BrSpSi.* II. 62; *KK.* I. 24.

Also *SuSi.* II. 64; *ŚiDVṛ.* I. ii. 23 (i); *SiŚe.* III. 75; *SiŚi.* I. ii. 67.

34. Rule pertaining to direct and retrograde motions of a planet : *BrSpSi.* II. 50-51.

Also *MBh.* IV. 56-57 ; *SiŚe.* III. 59 ; *ŚiDVṛ.* I. ii. 42 ;

35. A rule for converting true distances known in minutes into true distances into *yojanas* : for example : Sun's true distance in *yojanas*

$$\frac{\text{Sun's mean distance in } yojanas \times \text{Sun's true dist. in minutes}}{\text{Radius}}$$

BrSpSi. XXI. 31 (ii).

Also *MBh.* V. 3 ; *ŚiDVṛ.* I. iv. 5 (i) ; *LBh.* IV. 3 ; *SiŚe.* V. 4 (ii) ; *SiŚi.* I. v. 5 (i) ;

36. Rule for finding angular diameters of the Sun and the Moon : *BrSpSi.* XXI. 34 (ii) ;

Also *MBh.* V. 5 : *ŚiDVṛ.* I. iv. 8 ; *SiŚe.* V. 6 ; *SiŚi.* I. v. 7,

37. Formulae for the true (i. e. angular) diameters of the Sun, the Moon and the shadow in terms of the true daily motions of the Sun and the Moon (Here by shadow is meant the section of the cone of the Earth's shadow at the Moon's distance.) : *BrSpSi.* IV. 6 (i) ; *KK.* IV. 2 (i).

Also *MBh.* V. 6-7 ; *ŚiDVṛ.* I. iv. 9 ; *MSi.* V. 5 (ii) ;

SiŚe. V. 9 ; *SiŚi.* I. v. 8-9 ;

38. Rule for finding the *spaṣṭa-valana* (resultant *valana*) for the circle drawn with half the sum of the diameters of the eclipsed and eclipsing bodies as radius : *ErSpS.* IV. 18 (i).

Also *MBh.* V. 46 ; *ŚiDVṛ.* I. iv. 26.

39. Method for calculating the phase of the eclipse for the given time : *BrSpSi.* IV. 11-12.

Also *MBh.* V. 62-63 ; *ŚiDVṛ.* I. iv. 19-20 ; *SiŚe.* V. 14.

40. Rule for the determination of the diameter of the shadow i.e., the diameter of the Section of the Earth's shadow where the Moon crosses it : *BrSpSi.* XXIII. 8-9.

Also *MBh.* V. 71-73 ; *Ārya.* IV. 39-40 ; *ŚiDVṛ.* I. iv. 6 (ii)-7.

41. Process of successive approximations in connection with calculations of a lunar eclipse : *BrSpSi.* IV. 8-9.

Also *MBh.* V. 75-76 ; *LBh.* IV. 10-12 ; *ŚiDVṛ.* I. iv. 14-16 ; *SiŚe.* V. 12-13 ; *SiŚi.* I. v. 12-13.

42. Rule relating to the visibility-correction known as *akṣa-dṛkkarma* : *BrSpSi*. VI. 4.

Also *MBh*. VI. 1-2 ; *ŚiDV*. I. vii. 3 (ii) ; *MSi*. VII. 4 ; *SiŚe*. IX. 7.

43. Rule relating to the visibility correction known as *ayanadṛkkarma* : *BrSpSi*. VI. 3 ; X. 17.

Slightly modified in *MBh*. VI. 2 (ii)-3 ; *ŚiDV*. I. vii. 2-3 (i) ; *SiŚe*. IX. 4-5 ; similar in *MSi*. VII. 2-3 ; more accurate in *SiŚi*. I. viii. 4-5.

44. Rule relating to the visibility of moon : *BrSpSi*. VI. 6 ; X. 32.

Also *MBh*. VI. 4-5 (i) *PSi*. V. 3 : *ŚiDV*. I. vii. 5 ; *SiŚe*. IX. 8 (i). 13.

45. Rule for calculating the phase of the Moon : *BrSpSi*. VII. 11 (ii)-12.

Also *MBh*. VI. 5 (ii)-7 ; *ŚiDV*. I. ix. 12.

46. Rule for the determination of the Moon's true declination (i.e. the declination of the centre of the Moon's disc) : *BrSpSi*. VII. 5.

Also *MBh*. VI. 8 ; *ŚiDV*. I. viii. 2 ; *SiŚe*. X. 7. (these are approximate rules ; a more accurate rule occurs in *SiŚi*. I. vii. 3 and 13).

47. Graphical representation of the elevation of the lunar horns in the first quarter of the month at sunset : *BrSpSi*. VII. 7-10.

Also *MBh*. VI. 13-17 ; *ŚiDV*. I. ix ; *SiŚi*. I. ix.

48. Minimum distances of the planets from the Sun when they are visible : *BrSpSi*. vi 6 ; X. 32.

Also *MBh*. VI. 44 ; *ŚiDV*. I. vii. 5 (i) ; *SiŚe*. IX. 8 (i). 12.

49. Rule relating to the determination of the time and the common longitude of two planets when they are in conjunction in longitude : *BrSpSi*. IX. 5-6.

Also *MBh*. VI. 49-51 ; *ŚiDV*. I. x. 7-9 (i) ; *SiŚe*. XI. 12-12.

50. Rule relating to the distance between two planets

which are in conjunction in longitude : *BrSpSi*. IX. 11.

Also *MBh*. VI. 54 ; *ŚiDVṛ*. I. x. 11 ; *SiŚe*. XI. 10.

51. Rule For finding the *Bhujaphala* and *Koṭiphala* etc. without the use of the RSine-difference table : *BrSpSi*. XIV. 23-24.

Also *MBh*. VII. 17-19 ; *SiŚe*. III. 17.

52. To obtain the Sun's mean true longitude derived from the midday shadow of the gnomon : *BrSpSi*. XIV. 28; III. 61-62.

Also *MBh*. VIII. 5; *SiŚi* I. ii. 45.

53. Rule to find the arc corresponding to a given RSine : *BrSpSi* II. 11.

Also *MBh*. VIII. 6; *SuSi*. II. 33, *ŚiDVṛ*. I. ii. 13, *SiŚe*. III. 16, *SiŚi*. I. ii. 11 (ii)—12 (i).

For the concordance given here we express our indebtedness to the work of K.S. Shukla on the *Mahābhāskariya*.

Tables of Constants

Some of the Tables of Constants have been given in an earlier chapter. We here give a few more tables which would indicate how far Brahmagupta introduced new concepts in evaluating these constants of greater accuracy and refinement.

TABLE I

Position of Planets for the Beginning of *kaliyuga*

In this Table are given the positions of the planets, including the Moon's apogee and ascending node, for the beginning of *Kaliyuga*. The calculations of Brahmagupta are different from those of the *Sūryasiddhānta* and of Āryabhaṭa I,

Planet	Positions <i>BrSpSi</i> .	according <i>Ārya</i> .	to <i>SuSi</i>
1	2	3	4
Sun	$\begin{smallmatrix} s & o & ' & '' \\ 0 & 0 & 0 & 0 \end{smallmatrix}$	$\begin{smallmatrix} s & o & ' & '' \\ 0 & 0 & 0 & 0 \end{smallmatrix}$	$\begin{smallmatrix} s & o & ' & '' \\ 0 & 0 & 0 & 0 \end{smallmatrix}$
Moon	$\begin{smallmatrix} s & o & ' & '' \\ 0 & 0 & 0 & 0 \end{smallmatrix}$	$\begin{smallmatrix} s & o & ' & '' \\ 0 & 0 & 0 & 0 \end{smallmatrix}$	$\begin{smallmatrix} s & o & ' & '' \\ 0 & 0 & 0 & 0 \end{smallmatrix}$

1	2	3	4
	^s ° ' "	^s ° ' "	^s ° ' "
Moon's apogee	4 5 29 46	3 0 0 0	3 0 0 0
Moon's asc. node	5 3 12 58	6 0 0 0	6 0 0 0
Mars	11 29 3 50	0 0 0 0	6 0 0 0
Mercury	11 27 24 29	0 0 0 0	0 0 0 0
Jupiter	11 29 27 36	0 0 0 0	0 0 0 0
Venus	11 28 42 14	0 0 0 0	0 0 0 0
Saturn	11 28 46 34	0 0 0 0	0 0 0 0

TABLE II

Diameters of the Sun, the Moon and the Earth
in *yojanas* and the distances of the Sun
and the Moon from the Earth

	BrSpSi Bhāskara I	Śrīpati Bhāskara II	Modern (in miles)		
1	2	3	4	5	6
Sun's diameter in <i>yojanas</i>	6,522	4,410	6,522	6,522	86,400
Sun's distance in <i>yojanas</i> (mid- night reck.)	689,358	459,585	684,870	689,377	92,900,000
Ratio		0.009596	0.009,523	0.009,461	0.0093
Moon's diameter in <i>yojanas</i>	480	315	480	400	2,160
Moon's distance in <i>yojanas</i> (mid- night reck.)	51,566	34,377	51,566	51,566	2,389,000
Ratio Earth's dia- meter in <i>yojanas</i>	1.581	0.009,163	0.009,308	0.009,308	0.009

TABLE III

Sidereal Revolutions of the Apogees
of the Planets in a Kalpa

Apogee of	<i>BrSpSi.</i>	According to <i>Sūrya-Siddhānta</i>	<i>Āryabhaṭīya</i>
1	2	3	4
Sun	480	387	not given
Mars	292	204	
Mercury	332	368	
Jupiter	855	900	
Venus	653	535	
Saturn	41	39	

TABLE IV

Sidereal Revolutions of the Nodes
of the Planets in a Kalpa

(Not given in the <i>Āryabhaṭīya</i>)		<i>Sūrya-Siddhānta</i>
Node of	<i>BrSpSi.</i>	
1	2	3
Mars	267	214
Mercury	521	488
Jupiter	63	174
Venus	893	903
Saturn	584	662

TABLE V
Peripheries of the Epicycles
of the Planets

Planet	<i>BrSpSi.</i>		<i>Sūrya-Siddhānta</i>		<i>Āryabhaṭṭya</i>	
	odd quad.	even quad.	odd quad.	even quad.	odd quad.	even quad.
1	2		3		4	

(a) *Manda* epicycles

Sun	13°40'		13°40'	14°	13°30'	
Moon	31°36'		31°40'	32°	31°30'	
Mars	70°		72°	75°	63°	81°
Mercury	38°		28°	30°	31°30'	22°30'
Jupiter	33°		32°	33°	31°30'	36°
Venus	9°	11°	11°	12°	18°	9°
Saturn	30°		48°	49°	40°30'	58°30'

(b) *Śighra* epicycles

1	2		3		4	
Mars	243°40' ¹		232°	235°	238°30'	229°30'
Mercury	132°		132°	133°	139°30'	130°30'
Jupiter	68°		72°	70°	72°	67°30'
Venus	263°	258°	260°	262°	265°30'	256°30'
Saturn	35°		40°	39°	40°30'	36°

1. In the middle of quadrants. it is 237°

TABLE VI
Mean Diameters of the Planets

Planet	<i>BrSpSi.</i>	<i>Sūrya-Sid- dhānta</i>	<i>Āryabhaṭṭya</i>	Modern
1	2	3	4	5
Sun	32'31"	32'24"	33' approx.	32'2'36"
Moon	32' 1" approx.	32'	31'30"	31'8"
Mars	4'46"	2'	1'17"	9'36"
Mercury	6'14"	3'	2'8"	6'68"
Jupiter	7'22"	3'30"	3'12"	3'14.72"
Venus	9'	4'	6'24"	16.8"
Saturn	5'24"	2'30"	1'36"	2'49.5"

TABLE VII
Inclination of the Orbits of
the Planets to the Ecliptic

Planet	<i>BrSpSi.</i>	<i>Sūrya-Sid- dhānta</i>	<i>Āryabhaṭṭya</i>	Modern (Jan.00,195°)
1	2	3	4	5
Moon	4°30'	4°30'	4°30'	5°8'40"
Mars	1°50'	1°30'	1°30'	1°51'0"
Mercury	2°32'	2°	2°	7°0'14"
Jupiter	1°16'	1°	1°	1°18'21"
Venus	2°16'	2°	2°	2°23'39"
Saturn	2°10'	2°	2°	2°29'25"

TABLE VIII
Longitudes of the Junction Stars
according to Different Authorities

Junction-star of	Longitude (polar) according to		Longitude according to		
	<i>BrSpSi.KK. SiSi.</i>	<i>SiSe.SuSi</i>	<i>MBh.</i>	<i>LBh.</i>	<i>SiDVr.</i>
1	2	3	4	5	6
Aśvini	8°	8°	8°	8°	8°
Bharaṇi	20°	20°	27°	26°30'	20°
Kṛttikā	37°28'	37°30'	36°	36°	36°
Rohiṇi	49°28'	49°30'	49°	50°	49°
Mṛgaśīrā	63°	63°	62°	62°	62°
Ārdrā	67°	67°20'	70°	70°	70°
Punarvasū	93°	93°	92°	92°	92°
Puṣya	106°	106°	105°	105°	105°
Āśleṣā	108°	109°	114°	114°	114°
Maghā	129°	129°	128°30'	128°30'	128°
P-Phālgunī	147°	144°	141°	141°	139°20'
U-Phālgunī	155°	155°	154°	154°	154°
Hasta	170°	170°	173°	173°	173°
Citrā	183°	180°	185°	185°	184°20'
Svāti	199°	199°	197°	197°	197°
Viśakha	212°5'	213°	212°	212°	212°
Anurādhā	224°5'	224°	222°	222°	222°
Jyeṣṭhā	229°5'	229°	228°	228°	228°
Mūla	241°	241°	241°	241°30'	241°
P-Āṣāḍhā	254°	254°	254°	254°30'	254°

1	2	3	4	5	6
U-Āṣādhā	260°	260°	267°	266°30'	267°20'
Śravaṇa	278°	280°	285°	284°30'	284°10'
Dhaniṣṭhā	290°	290°	296°	295°30'	296°20'
Śatabhiṣak	320°	320°	307°	307°	313°20'
P-Bhādra.	326°	326°	328°	328°	327°
U-Bhādra	337°	337°	345°	345°	335°20'
Revati	0°	359°50'	360°	360°	359°

TABLE IX

Celestial Latitudes of
the Junction-Stars

Junction star of	Polar latitude given in			Latitude given in		
	<i>BrSpSi.KK. SūSi. SiSi.</i>			<i>MBh. LBh. ŚiDVr.</i>		
1	2	3	4	5	6	7
Aśvinī	10°N	10°N	10°N	10°N	10°N	10°N
Bharanī	12°N	12°N	12°N	12°N	12°N	12°N
Kṛttikā	4°31'N	5°N	4°30'N	5°N	5°N	5°N
Rohiṇī	4°33'S	5°S	4°30'S	5°S	5°S	5°S
Mṛgaśīrī	10°S	10°S	10°S	10°S	10°S	10°S
Ārdrā	9°S	9°S	9°S	9°S	9°S	9°S
Punarvasū	6°N	6°N	6°N	6°N	6°N	6°N
Puṣya	0	0	0	0	0	0
Āśleṣā	7°S	7°S	7°S	7°S	7°S	7°S
Maghā	0	0	0	0	0	0
P-Phālgunī	12°N	12°N	12°N	12°N	12°N	12°N
U-Phālgunī	13°N	13°N	13°N	13°N	13°N	13°N

1	2	3
Hasta	11°S	11°S
Citrā	1°45'S	2°S
Svāti	37°N	37°N
Viśakhā	1°23'S	1°30'S
Anurādhā	1°44'S	3°S
Jyeṣṭhā	3°30'S	4°S
Mūla	8°30'S	9°S
P-Āṣādhā	5°20'S	5°30'S
U-Āṣādhā	5°S	5°S
Śravaṇa	30°N	30°N
Dhaniṣṭhā	36°N	36°N
Śatabhiṣak	18'S	30'S
P-Bhādra	24°N	24°N
U-Bhādra	26°N	26°N
Revatī	0	0

backing to the west) in one day. It is sufficient to postulate the existence of only one Sun, one Moon and twenty-seven nakṣatras to explain the astronomical phenomena.¹

3. Brahmagupta differs from Āryabhaṭa I in the length of the four *yugas*. Āryabhaṭa regards all the four *yugas* of equal lengths, i. e. 1,080,000 years; the *caturyuga* being of 4,320,000 years. Brahmagupta regards *Kaliyuga* to be of 432,000 years, *Dvāpara* to be twice of it, *Tretā* to be thrice of it and *Kṛtayuga* of four times of the length of the *Kaliyuga*. Both have the *caturyuga* of the same length.²

4. Āryabhaṭa was not clear with respect to the number of civil days (*sāvana dina*) in a *yuga*; in one of his treatises he gives this number to be 1,577,917,800 and in the other 1,577,917,500 with a difference of 300 days, though in both the treatises, Āryabhaṭa I regards the number of solar years to be 4,320,000 in a *Caturyuga* or *Mahāyuga*. Why is this difference? asks Brahmagupta.³

5. Āryabhaṭa regards *mandocca* (the apogee) and *pāta* (the ascending node of the orbit on the ecliptic) as constant or stationary; then how could he propound a *sphuṭa-yuga* or the concept of true *yuga* with the concurrence of year, month and day on the Caitra Śukla Pratipadā (the first day of bright half of the month Caitra) at the same time as indicated by Āryabhaṭa in his *Laghvāryabhaṭiya Tantra*.⁴

Āryabhaṭa was not clear in respect to the variance in the *pāta*. In the *Āryaṣṭa-śata* (in the *Āryabhaṭiya* which has 108 Ārya verses), Āryabhaṭa states that the *pāta* of all the planets

1. मानिचतुस्फुत्ताराद्द्वौ द्वावर्कैर्द्वौ जिनोक्तं यत् ।
भ्रमरस्तस्यावर्त्तौ भवति यतोऽन्धा ततस्तदसत् ॥ BrSpSi. XI. 3
2. आर्यमदोयुगपादांस्त्रीन् यातानाह कलिष गादौ यत् ।
तस्यकृतान्तर्गत्मात् स्वयुगाद्यन्तौ न तत् तस्मात् ॥ —BrSpSi. XI. 4
3. युगरविमन्थाः स्युधिति वृत्तप्रोक्तं तत् त्वोर्युगं स्पष्टम् ।
त्रिशती स्युद्धवानां तदन्तरं हेतुना केन ॥ —BrSpSi. XI. 5
4. युगवर्षादीन् वदताचैत्रसितादेः समं प्रवृत्तान् यत् ।
तदसत् यतः स्युद्धुगं तत् स्वर्षाभ्यन्तर्गतानाम् ॥ —BrSpSi. XI. 6

show variance of movement, but in the *Daśagītikā* (a chapter of ten *Āryā* verses), he states that with the exception of the *pāta* or the Moon, the *pāta*'s of all other planets are stationary or constant. Brahmagupta points out this anomaly in the concept of *Āryabhaṭa*.¹

6. Brahmagupta points out a self-contradiction in *Āryabhaṭa*. At one place he says that the Moon covers the Sun during the solar eclipse and similarly the shadow of the Earth covers the Moon during the lunar eclipse (and he does not mention *Rāhu*) in this connection (*Āryabhaṭīya*, Gola. 37). At the same time it is said that *Āryabhaṭa* was familiar with the movement of "eight" planets, and thus postulating the presence of *Rāhu*; in fact, the *pātas* of planets are responsible for their eclipses, and the eighth planet *Rāhu* is not present.²

7. *Āryabhaṭa* gives measures to Manus, Yugas and Kalpas different from what have been given in the recognised *Smṛtis*.³

8. *Āryabhaṭa* regards *Guruvāra* or Thursday to be the first day of the *Kalpa*, and not Sunday, which is wrong according to Brahmagupta.⁴

9. Brahmagupta unnecessarily criticises *Āryabhaṭa* in respect to the order of days. The motion of the planets decreases in the following order : Moon, *Budha* (Mercury), *Sukra* (Venus), Sun, *Kuja* (Mars), *Guru* (Jupiter) and *Śani* (Saturn). *Āryabhaṭa* in one of his verses states that starting from the Sun and proceeding in the increasing order every fourth is the *dinapati* or the "lord of the day" (*Āryabhaṭīya*, Kāla. 16) ; this gives the order : Sun, Moon, Mars, Mercury, Venus and Saturn and hence the order of days as *Ravivāra* (Sunday); *Candravāra* (Monday);

1. आर्याष्टशते पाता भ्रमन्ति दशगीतिके स्थिराः पाताः ।

मुत्तवेन्दु पातमपमण्डले भ्रमन्ति स्थिरा नातः ॥

—*BrSpSi*. XI. 8

2. आर्यभटो जानाति ग्रहाद्यगतिं यदुक्तवांस्तदसत् ।

राहुकृतं न ग्रहणं तत्पातो नाष्टमो राहुः ॥

—*BrSpSi*. XI. 9

3. समामनुयुगकल्पाः कल्पादिगतं कृतादियातं च ।

स्मृत्युक्तं आर्यभटो नातो जानाति मध्यगतिम् ॥

—*BrSpSi*. XI. 10

4. ओङ्कारो दिनवारो रुरौददिकोऽस्य भवति कल्पादौ ।

न भवत्यर्को यस्मादोङ्कारो विस्तरस्तस्मात् ॥

—*BrSpSi*. XI. 11

Mangalavāra (Tuesday), (*Budhavāra*) (Wednesday), *Guruvāra* (Thursday) *Sukravāra* (Friday) and *Śanivāra* (Saturday). Thus Āryabhaṭa gives the same order of days as other authorities and there is no reason why he should be criticised.

Certainly what is Sunday for *Laṅkā*, may not be Sunday at the same time for *Siddhapura*; and Āryabhaṭa should have emphasised that the day (Monday, Tuesday etc.) is not constant for all the places.¹

10. Brahmagupta expresses surprise why Āryabhaṭa, in two of his treatises propounds two different systems of reckoning one from the Sunrise in *Laṅkā* and the other from the Midnight in *Laṅkā*.² This causes a difference of one-fourth of the daily-motion in the two reckonings of the motion of planets.³

11. Brahmagupta criticises Āryabhaṭa on the point of diameter of the Earth. In the *Gatikapāda*, 5 and 6, Āryabhaṭa states that one *yojana*=8,000 × *puruṣa*, and 1 *puruṣa*=4 *hasta*, thus 1 *yojana*=32,000 *puruṣas*, and the diameter of the Earth is 1050 *yojanas*. Brahmagupta further says that an error in the diameter of the Earth would cause an error in *deśāntara* or longitude and thus also in the true *ṭīthi* and consequently in the calculation of eclipses also.⁴

12. Āryabhaṭa has rightly stated that the Earth is in motion and the *Bhaganas* are stationary. Brahmagupta's objection is that if the Earth is in motion, birds would not be able to return to their nests, and if the Earth's motion is upside-down,

1. सूर्यादयस्चतुर्था दिनवारा यदुक्ता तदसदार्थमदः ।

लङ्कोदयो यतोऽर्कं स्वास्तमयं ग्राहं सिद्धपुरे ॥

— *BrSpSi*. XI. 12

2. अधिकैः शतैश्चतुर्भिर्वर्षसहस्रैश्चतुर्दशभिरेकः ।

युगपारं दिनवारान्तरं मौदयिकार्थं रात्रिकयोः ॥

— *BrSpSi*. XI. 13.

3. औदयिकादिनमुक्ते स्तुर्याशौ नार्थं रात्रिको भवत्यूनः ।

कतरं स्फुटं न निश्चितमनयोः स्फुटमेकमपि नातः ॥

— *BrSpSi*. XI. 14

4. षोडशगद्विचोच्चनरिधिं प्रतिभूव्याप्तं पुलावदत्ता ।

आत्मयमानं रय्यापितमनिश्चयस्तस्मिन् कृतकन्यात् ॥

मूल्यासत्त्वाहानाद् व्यर्थं देशान्तरं तद्वानाह ॥

स्फुटतिष्ठत्वाच्च तिथिनासाद् ग्रहखयोर्नाशः ॥

— *BrSpSi*. XI. 15-16

then the roof and hills would come down, which is contrary to our observation.¹ Obviously Brahmagupta is not justified in his criticism.

13. Brahmagupta points out to the differences in his calculations and the calculations of Āryabhaṭa in the peripheries of the *manda* and *śighra* epicycles of planets in the odd and even quadrants. (This difference we have shown in Table V, p. 313)²

14. Āryabhaṭa I and Bhāskara I have both given a rule for the determination of the *ḍṛkkṣepajyā*s of the Sun and the Moon :

Take the product of the Sun's or Moon's own *madhyajyā* and *udayajyā*, then divide the product by the radius and then take the square of the quotient. Subtract that from the square of the own *madhyajyā* ; the square-root of that difference is known as the Sun's or Moon's *ḍṛkkṣepajyā*.³

The Sun's *ḍṛkkṣepajyā* is the Rsine of the zenith distance of that point of the ecliptic which is at the shortest distance from the zenith (this point is called nonagesimal or the central ecliptic point). The Moon's *ḍṛkkṣepajyā* is the Rsine of the zenith distance of that point of the Moon's orbit which is at the shortest distance from the zenith. The rule given above is only approximate and has been criticised by Brahmagupta.⁴

15. In the *Āryabhaṭīya*, there is a rule in the Golapāda for finding the Rsine of the *agra* of the true Sun; and also for the

1. प्राणैर्नैति कलां भूर्यदि तर्हि कुतो ब्रजेत् कमध्वानम् ।

आवर्तनमुर्व्याश्चेन्न पतन्ति समुच्छ्रयाः कस्मात् ॥

—*BrSpSi*. XI. 17

2. औदयिको यः परिधिर्विषमेऽन्योमेऽन्यः समे भुजस्य गुणः ।

तदसद्विषमान्तफलं यतो न युग्मादि फलतुल्यम् ॥

विषमेऽन्योऽन्यो युग्मे परिधिरुणकः क्रमोत्क्रमज्यानाम् ।

चक्रार्धे फलनाशो न भवति यस्मादसत् तदपि ।

—*BrSpSi*. XI. 18-19

3. स्वमध्यज्योदबाभ्यासं विष्कम्भाधीतवर्गितम् ॥

मध्यज्यावर्गतोऽपास्य स्वदृक् क्षेत्रं पदं विदुः ॥

—*Mbh*. V. 19

4. विभिन्नभरणे दृक्क्षेपमण्डलं तदपमण्डलयुतौ ज्या ।

मध्यादृक्क्षेपज्या नार्धभदोक्ताऽनया तुल्या ॥

दृक्क्षेपज्याऽतोऽसत् तन्नाशादवनतेर्नाशः ।

अवनतिनाशात् यासस्योनाधिकता रविग्रहणे ॥

—*BrSpSi*. XI. 29-30

Rsine of the Sun's prime vertical altitude.¹ Bhāskara also gives the rule in his *Mahābhāskariya* :

Multiply the Rsine of the (Sun's) greatest declination by the Rsine of the Sun's true (*sāyana*) longitude; then divide (the product) by the Rsine of the colatitude, the result is (the Rsine of) the *agra* of the true Sun. When that (*agra*) is less than the latitude and when the Sun is also in the northern hemisphere, multiply (the Rsine of the Sun's *agra*) by (the Rsine of) the colatitude; the result is the Rsine of the Sun's prime vertical altitude.³

The condition laid down in the rule that the "Sun's *agra* should be less than the latitude" is incorrect. The error was originally committed by Āryabhaṭa and Bhāskara followed it. This error was noticed by Brahmagupta³. Bhāskara I, however, corrected the error in the *Laghu-Bhāskariya*. There he gives the correct conditions. It is not the *agra* that should be less than the latitude, it is the Sun's declination (or rather the Rsine of the Sun's northern declination as we have in the *Laghu-Bhāskariya*), which should be less than the latitude (or rather the Rsine of the latitude). This condition is necessary for the existence of the prime vertical shadow of the gnomon.

It may be pointed out that the commentators of Āryabhaṭa I have interpreted the rule given by Āryabhaṭa I as conveying the correct meaning; they say that Āryabhaṭa also meant declination when he used the term *agra*.

1. परमापक्रमजीवामिष्टव्यार्थाहतां ततो विभजेत् ।
ज्यालम्बकेन लम्बाकांया पूर्वापरे क्षितिजे ॥
सा विषुवज्ज्योना चेद् विषुवदुदङ्गलम्बकेन संगुणिता ।
विषुवज्ज्यया विभक्ता लम्बः पूर्वापरे शंकुः ॥

—Ārya. V. 30-31

2. स्फुटरविमुजनिष्ठां यां परां क्रांतिजीवां ।
हरतु समवलम्बज्या कलापेन भूयः ॥
स्फुट दिक्स कराया सा यदाऽक्षांशहीना ।
रक्तिरपि यदिगोले चोत्तरे लम्बकन्ताम् ॥
अक्षज्या हरेद् भूयः शंकुः स्यात् सममण्डले ।
तद् कर्गं व्याप्त कृष्योर्यद् विश्लेषं तत्पदं प्रमा ॥

—MBh. III. 37-38

3. स्फुटयोलेऽप्यायं विषुवज्ज्यतो यदुक्तमूनायाम् ।
सममण्डलमस्तदसत् क्रांतिज्यायां यतो भवति ॥

—BrSpSi. XI. 22

Usually by *agra*, we mean the arc of the celestial horizon lying between the east point and the point where a heavenly body rises; or between the west point and the point where a heavenly body sets. Declination is *krānti*.

16. Brahmagupta has criticised Āryabhaṭa and his group for their expressions for determining *lambana* (i. e. the difference of the parallaxes, in longitude, of the Sun and the Moon), and the rule for determining the *avanati* or *nati* (i.e. the difference in parallaxes, in latitude of the Sun and Moon).¹

Lambana is obtained with the help of the five Rsines : (i) *madhya-jyā*, (ii) *udaya-jyā*, (iii) *ḍṛk-kṣepa-jyā*, (iv) *ḍṛg-jyā*, and (v) *ḍṛg-gati-jyā*.

(i) The *madhyajyā* is the Rsine of the zenith distance of meridian ecliptic point :

$madhyajyā = R \sin (\phi \pm \text{declination of the meridian ecliptic point})$.²

In this expression ϕ is the latitude of the place, and by $R \sin$ is meant $R \times \text{sine}$, R being the radius of the celestial sphere.

(ii) The *udayajyā* is the Rsine of the arc of the horizon intervening between the equator and the ecliptic, and is given by :

$$udayajyā = \frac{R \sin L \times R \sin e}{R \cos \phi}$$

where L is the longitude of the horizon ecliptic point in the east, and e the obliquity of the ecliptic.

(iii) The *ḍṛkksepajyā* is the R sine of the zenith distance of the central ecliptic point³, and is given by :

1. व्यासार्धेन विभक्ता दृग्गति जीवा चतुर्गुणा लब्धम् ।

लम्बननाड्यः पञ्चदशगुणितया विज्यया भक्ता ॥

दृक्क्षेपज्या भुक्तयन्तराहता लब्धमवनतिर्भवति ।

स्फुटयोन्नतकर्णाभ्यां भूज्याः न च विना स्पष्टे ॥

आर्यभटेनास्मिन् सति लघुनि विमर्थं महत् कृतं कर्म ।

गणितज्ञानाज्जाड्यं विज्ञानता यदि ततः सुतराम् ॥

—BrSpSi. XI. 23-25

2. The meridian ecliptic point is the point of the ecliptic on the meridian.

3. The central ecliptic point is the central point of the portion of the ecliptic lying above the horizon.

$drkkṣepajyā$

$$= \left[(madhyajyā)^2 - \left\{ \frac{udayajyā \times madhyajyā}{R} \right\}^2 \right]^{\frac{1}{2}}$$

where R is the radius of the celestial sphere.

(iv) The $dr̥gjyā$ is the Rsine of the zenith distance (of the Sun) and is given by :

$$dr̥gjyā = \left[R^2 - \left\{ \frac{dr̥ggatijyā \times R \sin(L - \theta)}{R} \right\}^2 \right]^{\frac{1}{2}}$$

where L is the longitude of the horizon ecliptic in the east and θ the longitude of the Sun.

(v) The $dr̥ggatijyā$ is the Rsine of the altitude of the central ecliptic point, and is given by :

$$dr̥ggatijyā = [R^2 - (drkkṣepajyā)^2]^{\frac{1}{2}}$$

where R is the radius of the celestial sphere.

In the *Mahābhāskarīya*¹, the expression for the Sun's $dr̥ggatijyā$ is :

$$\begin{aligned} & (\text{Sun's } dr̥ggatijyā)^2 \\ &= (\text{Sun's } dr̥gjyā)^2 - (\text{Sun's } drkkṣepajyā)^2 \end{aligned}$$

and similar is the expression for the the Moon's $dr̥ggatijyā$.

Now *lambana*, which is the difference of the parallaxes, in longitude, of the Sun and the Moon, is given by the expression :

$$Lambana = \text{Moon's } lambana - \text{Sun's } lambana.$$

Sun's *lambana*

$$= \frac{\text{Sun's } dr̥ggatijyā \times \text{Earth's semidiameter}}{\text{Sun's true distance in } yojanas}$$

Moon's *lambana*

$$= \frac{\text{Moon's } dr̥ggatijyā \times \text{Earth's semi-diameter}}{\text{Moon's true distance in } yojanas}$$

These *lambanas* are in terms of minutes of arc etc².

1. स्वहृदये प शुणयोर्वर्गं विरलेषजे पदे ।

हमतिज्ये भवेतां ते भास्करामृत तेजसः ॥

—MBh. V, 23

2. स्वहृदयेष्वमा व्यास मेद संवर्गं संभवम् ।

पृथक्पृथक् कर्त्तव्यं लिप्ताच्च लम्बनं किन्दुः ॥

Thus *lambana* is given by subtracting the Sun's *lambana* from Moon's *lambana*.

This *lambana* is also expressed in the following way .

Lambana

$$= \left[\frac{\{(drgiyā)^2 - (dykkṣepajyā)^2\}^{1/2} \times 18}{\text{Moon's true distance}} - \frac{\{(drgiyā)^2 - (dykkṣepajyā)^2\}^{1/2} \times 18}{\text{Sun's true distance}} \right]$$

in minutes.

$$= \frac{60}{d} \times (\text{lambana calculated in minutes}) \text{ is the}$$

lambana in *ghaṭis*, where *d* denotes the difference between the daily motions of the Sun and the Moon.

Aryabhaṭa I has given his description of the determination of *lambana* and *avanati* in the Golapāda 33, 34 of the *Āryabhaṭīya*¹, and Bhāskara has followed his rules in the *Mahābhāskarīya*². Brahmagupta criticises them in his *Brāhma-sphuṭasiddhānta*³.

(vii) We shall now take up *nati* or *avanati* (both the terms mean the same). *Nati* is the difference of the parallaxes in latitude, of the Sun and the Moon and is given by :

$$\text{nati} = \left[\frac{dykkṣepajyā \times 18}{\text{Moon's true dist.}} - \frac{dykkṣepajyā \times 18}{\text{Sun's true dist.}} \right]$$

minutes.

(Cont. from Page 324)

तद्विशेषो हतः षष्ठ्या स्फुटमुक्त्यन्तरोदधुतः ।

घटिकादिस्तिथेः प्राहणे शुद्धिः क्षेपोऽपरे मतः ॥

दिनार्धकालनिष्पन्नं लम्बनं शोच्यते तिथेः ।

उदगिन्दूदयज्यायां दीयते तत्र दक्षिणे ॥

एवं पुनः पुनः कर्म यावत्तदविशिष्यते ।

तिथिवच्चन्द्रतीक्ष्णांशू सञ्च विव पण्डितैः ॥

—MBh. V. 24-27

1. मध्यज्योदयजीवासंवर्गे व्यासदलहते यत् स्यात् ।

तन्मध्यज्याकृत्योर्विरोधमूलं स्वहृक्षेपः ॥

हृक्षेपः कृतिविशेषितस्यमूलं स्वहृगतिः कुवशम् ॥

चित्तिजे स्वहृक्षा भूज्यासार्धं नमोमध्यम् ॥

—Arya. IV. 33-34

2. loc. cit. MBh. V. 24-27

3. loc. cit. BrSpSi. XI. 23-25

(viii) Moon's true latitude = Moon's latitude \times *nati*.

The present *Sūryasiddhānta* and *Brahmagupta* both utilise the following expressions for *lambana* and *nati* which give more accurate values :

$$lambana = \frac{R \sin (M - \odot) \times drgati : yā}{\{R \sin (30^\circ)\}^2} \text{ ghaṭis}$$

where *M* and \odot denote the longitudes of the meridian ecliptic and the Sun respectively.

$$nati = \frac{drkkṣepajyā \times d}{15 \times R}$$

where *R* is the radius of the celestial sphere and *d* denotes the difference between the daily motions of the Sun and the Moon¹.

Brahmagupta has raised objections to the *Āryabhaṭa* system regarding *lambana* (XI. 26-28), *drkkṣepa* (XI. 30-31) *ayanadrkkarma* (XI. 35), elevation of Moon's horns (*śṛṅgonnati*) (XI. 39) and similar several other points. He is so vehemently opposed to *Āryabhaṭa* that finally he declares :

"It is beyond my capacity to enumerate all the defects of *Āryabhaṭa*. Only a few have been given here as illustration. Intelligent people can easily find out others².

He also says :

Āryabhaṭa is neither conversant with the *Gaṇita* (mathematics), nor *Kāla* (time calculations) nor *Gola* (celestial or spherical calculations). It is difficult to enumerate separately the fallacies committed by him in the respective chapters of the *Gaṇitapāda*, *Kālakriyāpāda* and *Golapāda*³.

1. loc. cit. *BrSpSi*. XI. 23.

2. भास्करदृक्खानां संख्या वक्तुं न शक्यते यस्मात् ।
तस्मादवमुद्देशो बुद्धिमताऽन्यानि योज्यानि ॥

—*BrSpSi*. XI. 44

3. ज्ञानात्येकमपि यतो नायंभट्टो गणितकालगोलानाम् ।
न मया प्रोक्तानि ततः पृथक् पृथक् दूषयान्धेषाम् ॥

—*BrSpSi*. XI. 43.

Brahmagupta and Śrīṣeṇa

In Varāhamihira's *Pāncasiddhāntikā* we have a critical review of the five *Siddhāntas* or five systems of astronomical study : Puliśa Siddhānta, Romaka Siddhānta, Vasiṣṭha Siddhānta, Sūrya Siddhānta and Brāhma Siddhānta. Colebrooke in his Paper "On the notion of the Hindu Astronomers concerning the precession of the equinoxes and motions of the planets", published in the *Asiatic Researches*, vol. xii. p. 203-250, Calcutta, 1816, to, reproduced in the *Miscellaneous Essays*. Vol. II. 1872, says the following in regards to the authorship of these schools of astronomy :

All these books are frequently cited in the astronomical compilations and are occasionally referred to their real or supposed authors. The first is everywhere assigned to Puliśa, whose name it bears. The *Romaka Siddhānta* is ascribed by the scholiast of Brahmagupta and by a commentator of the *Sūrya Siddhānta* to Śrīṣeṇa. The *Vāsiṣṭha Siddhānta* is by the same authority given to Viṣṇucandra. Both these authors are repeatedly mentioned with censure by Brahmagupta ; and it is acknowledged that they are entitled to no particular deference.

The *Brāhmṇa Siddhānta*, which is the basis of Brahmagupta's work, is not anywhere attributed to a known author ; but referred to in all quotations of it which have fallen under observation, either to the *Viṣṇudharmottara Purāṇa*, of which it is considered as forming a part, or to Brahmā (also called Pitāmaha) who is introduced into it as the speaker in a dialogue with Bhṛḡu, or it is acknowledged to be the work of some unknown person. The true author it may be now impracticable to discover, and would be vain to conjecture.

The *Sūrya Siddhānta* (if the same which we now possess) is in the like manner ascribed to no certain author unless in the passage cited by my colleague Mr. Bently (*Asiatic Researches*, vol. vi. p. 572) who says that "in the commentary of the *Bhāsvatī*, it is declared, that

Varāha was the author of the *Sūrya Siddhānta**, and who adds, that "Satānanda, the author of the *Bhāsvatī* was a pupil of Varāha under whose directions, he himself acknowledges, he wrote that work".

This concluding remark alludes to the following verse of the *Bhāsvatī Karaṇa* : "Next I will propound succinctly, from Mihira's instruction, (the system) equal to the *Sūrya Siddhānta*¹, (*Miscellaneous Essays*, p. 388-90) (The word 'Mihira' has double meaning : it might be an abbreviation of *Varāhamihira*, or it may mean sun or *Sūrya*).

Thus on the authority of Colebrooke, Śrīṣeṇa may be regarded as the initiator of the Romaka system. Brahmagupta himself mentions in one of his passages the name of Śrīṣeṇa in connection with the Romaka system, and further the conceptions of the Romaka system came down as Vāsiṣṭha system through Viṣṇucandra,² Lāṭadeva also derived from Śrīṣeṇa the concepts of the mean motions of the Sun, the Moon, the Moon's apogee and her node and the mean motions of Mars, Mercury's, *Śighra*, Jupiter, Venus' *śighra* and Saturn. I have indicated elsewhere, which is also the view of Sankara Bālakṛṣṇa Dikṣita, that the original Romaka and Pauliṣa Siddhāntas were introduced to Indians by Lāṭadeva, and the latter Romaka Siddhānta by Śrīṣeṇa (Original Romaka Siddhānta was prevalent before Śaka 427 and this is the one which is mentioned by Varāhamihira who makes no reference to Śrīṣeṇa and Viṣṇucandra in the *Pañcasiddhāntikā*, and the latter Romaka Siddhānta was introduced by Śrīṣeṇa as is indicated by Brahmagupta. Thus we have two Vāsiṣṭha Siddhāntas and two Romaka Siddhāntas). My personal view is that Lāṭadeva, Śrīṣeṇa and possibly Viṣṇucandra also, were naturalised Greeks, settled in India and they had adopted themselves to Indian life. They were conversant in Greek and Indian Astronomy both and had contributed substantially to Indian astronomy. Brahmagupta was opposed to any of these foreign influences dominating Indian

1. अथ प्रवक्ष्ये मिहिरोपदेशात् तत्पूर्वसिद्धान्तं समं समासात् ॥

—*Bhāsvatī Karaṇa*

2. श्रीमिसेन गृहीत्वा रज्ज्वररोमकः कृतः कथा ।

पञ्चमेव गृहीत्वा वसिष्ठो विष्णुकन्देख ॥

—*BrSpSi*. XI. 50

systems, and he very much resented such interferences in pure academic life of this country. He was opposed to Āryabhaṭa for a different reason. Āryabhaṭa was universally regarded as an authority in this country, and the conservatism was so deep that even where it could be shown by direct observation or on valid theoretical grounds, that a particular concept was erroneous or less accurate, people still chose to adhere to it, since they had the backing of Āryabhaṭa's authority. Brahmagupta was against this nonscientific attitude. Needless to say, Brahmagupta was not always fair to Āryabhaṭa in his criticism ; he overdid in enumerating the shortcomings of Āryabhaṭa's system, as if he was personally jealous of his wide popularity.

Brahmagupta's feelings against Lāṭadeva, Śrīṣeṇa, Viṣṇucandra and others would be seen from the following passage in the *Brāhmasphuṭasiddhānta* :

From the fact that Śrīṣeṇa, Viṣṇucandra, Pradyumna Āryabhaṭa, Lāṭa, and Simha contradict one another regarding eclipses and similar topics, their ignorance, is proved daily. The criticisms which I have passed on Āryabhaṭa are, with the requisite modifications, to be applied to the doctrines of each of these teachers as well. I will, however, make some further critical remarks on Śrīṣeṇa and others.

Śrīṣeṇa took from Lāṭa the rules concerning the mean motions of the Sun, and the Moon, the Moon's apogee and her node, and the mean motions of Mars, Mercury's Śighra, Jupiter, Venus's Śighra, and Saturn ; he took elapsed years and the revolutions of *yuga* (*yuga-yāta-varṣa-bhagana*) from Vasiṣṭha and the *Padakaraṇa* of Vijayānandi ; further took from Āryabhaṭa the rules concerning the apogee, epicycles and nodes, and those referring to the true motions of the planets and thus the *Romaka Siddhānta* which was (or is) a heap of jewels (as it were) has, by Śrīṣeṇa, been made into a patched rag (as it were)¹.

1. श्रीशिवविष्णुचन्द्र प्रद्युम्नार्यभट्टलटसिंहानाम् ।
ग्रहणादिकिंवादात् प्रतिदिक्कं दिगुणमन्त्रत्वम् ॥

Brahmagupta very emphatically says about his system that so long as people would be finding concordance between the observed and theoretical results (*dyggaṇitaikyam*) in respect of solar and lunar eclipses, his Brāhma Siddhānta would be held in esteem¹.

In other systems, whatever concordance appears to be between the observation and calculation, of eclipses etc., it is, Brahmagupta says, merely accidental or by chance, as the maxim of letters bored by an insect in wood or paper².

युत्तयाऽऽर्यभटोक्तानि प्रत्येकं दूषणानि योज्यानि ।

[Cont. from Page 329]

श्रीषेणप्रभृतीनां कानि चिदन्यानि वक्ष्यामि ॥

लाभात् सूर्यशार्ङ्गकौ मध्याविन्दूच्च चन्द्रपातौ च ।

कुजबुधश्रीप्रवृहत्पति सितशीघ्र शनैश्चरान् मध्यान् ॥

युगयातवर्षभगणान् वासिष्ठाद्विजयनन्दि कृतपादात् ।

मन्दोच्च परिधिपातस्पष्टीकरणाद्यमार्यभटात् ॥

श्रीषेणेन गृहीत्वा रक्षोच्चयरोमकः कृतः कन्धा ।

प्रतानेव गृहीत्वा वासिष्ठो विष्णुचन्द्रेण ॥

—BrSpSi. XII. 46-50

2. चन्द्ररवि ग्रहणेन्दुच्छायादिषु सर्वदा यतो ब्राह्मे ।

दृग्गणितैक्यं भवति त्पुनरिद्वान्तस्ततो ब्राह्मः ॥

—BrSpSi. XI. 61

3. अनयोर्न कदाचिदपि ग्रहणादिषु भवति दृष्टिगणितैक्यम् ।

यद्भवति तद् धुष्याच्चरमतोऽस्फुटभ्यां किमेताभ्याम् ॥

—BrSpSi. XI. 51.

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Brahmagupta and Astronomical Instruments

The Twenty-second Chapter of the *Brāhmasphuṭasiddhānta* is known as the *Yantrādhyāya* or a chapter on instruments. There is a description of seventeen types of time-reckoning instruments (*Kāla-yantra*)¹ :

1. Dhanuryantra—Bow instrument.
2. Turyaṅgolaka yantra—Quadrant (one-fourth sphere)
3. Cakra yantra=wheel or circle.
4. Yaṣṭi yantra—a pole or staff instrument.
5. Śaṅku yantra—Gnomon.
6. Ghaṭikā yantra—a clock or pot instrument.
7. Kapāla yantra—Bowl or potsherd instrument.
8. Karttari yantra—Scissor or knife ; cutter.
9. Piṭha yantra=Pedastal or seat instrument.
10. Salila yantra—Water-leveller.
11. Brahma or Śāṇa yantra—For describing circles.
12. Avalamba Sūtra—Threads with plumbs (Plumb lines).
13. Karṇa or chāyā-karṇa—A set of squares for diagonals.
14. Chāyā or śaṅku-chāyā—Sundial.

-
1. सप्तदश कालयन्त्राण्यतो धनुस्तुयं गोलकं चक्रम् ।
यष्टिः शङ्कुर्घटिका कपालकं कर्चरी पीठम् ॥
सलिलं भ्रमीऽवलम्बः कर्णश्चाया दिनार्थमर्कोऽङ्गः ।
नतकालज्ञानार्थं तेषां संसाधनान्यथै ॥

15. Dinārdha yantra—Midday measure instrument.
16. Arka yantra—Sun-instrument.
17. Akṣa or Palāṅśa yantra—Small degree measure arc instrument.

Salila yantra is used for levelling; since a liquid such as water seeks its own level, it can be utilised to know whether a surface has been levelled or not.¹ *Bhrama* or *Śāṇa* is used for drawing circles. *Avalambaka* or plumbline is used for adjusting vertical line. *Karṇa* is used in connection with angles and diagonals. From *Salila* (no. 10) to the last (no. 17); these eight are used for adjustments and are basically important.

The *dhanuryantra* is used for *nata* and *unnata* *kāla ghaṭikās*.

On the *paridhi* or the circumference of the *cakra-yantra* are indicated the twelve *rāsis*, ending up to *Mīna* (XXII. 18). Brahmagupta has described the *yaṣṭi yantra* and shown how it could be used to give time at different parts of the day, and from its shadow *dṛggyā* and other characteristics can be calculated. This instrument can also be used for ascertaining the solar-lunar differences, and for fixing up the directions. It can be used for determining various heights and altitudes.

The *karttari yantra* is of the shape of a pair of scissors with two semi-circular blades, fastened to a string at the centre; at the centre is fixed a pin or a pole which casts shadows.

Setting up of the Gnomon

Here it would be interesting to describe the setting of a gnomon, which K.S. Shukla has given in details while commenting on the *Mahābhāskariya* (IV. 1):

After having tested the level of the ground by means of water, draw a neat circle with a pair of compasses (*karkata*) (At the centre of that circle, set up a vertical gnomon). The gnomon should be large, cylindrical, massive, and tested for its perpendicularity by means of four threads with plumbs (*avalambaka*) tied to them.

1. सलिलेन समं साध्वं त्रमेख वृत्तमवलम्बकेनोर्ध्वम् ।

तिर्वक्ष्ये कथेनान्यैः कथितैश्च नव प्रवक्ष्यामि ॥

Bhāskara I in his commentary on the *Āryabhaṭīya* tells us that there was a difference of opinion amongst astronomers in his time regarding the shape and size of gnomon (also called style). Some astronomers prescribed a gnomon with its one-third in the bottom of the shape of a prism on a square base (*caturasra*), one-third in the middle of the shape of a cow's tail (*go-pucchākāra*), and one-third at the top of the shape of a spear-head (*Śulākāra*) and some others prescribed a square prismatic (*samacaturasra*), gnomon. The followers of Āryabhaṭa I, he informs us, prescribed the use of a broad (*prthu*), massive (*guru*), and large (*dirgha*) cylindrical gnomon, made of excellent timber and free from any hole, a scar or knot on its body. In the above stanza, Bhāskara I prescribes this last kind of gnomon: the other two kinds he proves in the commentary to be defective and so he rejects them.

For getting the shadow end easily and correctly the cylindrical gnomon was surmounted by a fine cylindrical iron or wooden nail fixed vertically at the centre of the upper end. The nail was taken to be longer than the radius of the gnomon, so that its shadow was always seen on the ground.

Certain writers, Bhāskara I tells us in the commentary, prescribed a gnomon of half a cubit (=12 *āṅgulas*) in length and having twelve divisions. But according to Bhāskara I (although it was the usual custom) there was no such hard and fast rule. The gnomon could be of any length and any number of divisions. The gnomon should, however, be large enough, so that the rings of graduation on the gnomon may be clearly seen on the shadow. A broad and massive gnomon was preferred because it was unaffected by the wind.

Brahmagupta describes gnomon which at the bottom is two *āṅgulas* wide, pointed as a needle, 12 *āṅgulas* in length, and full of holes from the basic circular part to the pointed extremity. (*BrSpSi*. XXII. 39).

As regards testing the level of the ground, Bhāskara I observes :

When there is no wind, place a jar (full) of water upon a tripod on the ground which has been made plane by means of eye or thread, and bore a (fine) hole (at the bottom of the jar) so that the water may

have continuous flow. Where the water falling on the ground spreads in a circle, there the ground is in perfect level ; where the water accumulates after departing from the circle of water, it is low ; and where the water does not reach, there it is high. (Bhāskara's Commentary on the *Āryabhaṭṭya*, II. 13).

After the ground was levelled, a prominently distinct circle was drawn on the ground as stated in the text (*MBh.* III. 1). In the time of Sankaranārāyaṇa (869 A.D.), there it seems that all lines were drawn on the ground with sandal paste (candanā-kṣodārdra). The above circle having been thus drawn and coated with sandal paste, another small concentric circle was drawn with the radius of the gnomon. The gnomon was then placed vertically with the periphery of its base in coincidence with that circle. The gnomon was thus set up exactly in the middle of the bigger circle. The verticality of the gnomon was tested by means of four plumb lines hung on the four sides of the gnomon

Gnomon Used for Finding the Directions

The rule in this connection has been described by Brahmagupta in *BrSpŚi.* III. 1. The same rule in other words has been described by Bhāskara I in *MBh.* III. 2. In the *Yāsanā Bhaṣya*, Pṛthūdaka Svāmī describes the details of determining the directions. The level of the ground is ascertained by means of water and a gnomon of 12 angulas is set up. Find out two points where the shadow of the gnomon enters into and passes out of the circle. Bhāskara prescribes drawing out a fish figure with these points. The thread line which goes through the mouth and tail of the fish figure indicates the north and south directions with respect to the gnomon. Brahmagupta says that if the Sun is on the eastern side, then where the shadow-point enters circle (in the forenoon) that point would be the west, and the point where it emerges out (in the afternoon) is the east.

As the Sun moves along the ecliptic, its declination changes. By the time the shadow moves between the forenoon and afternoon points as given above, the Sun traverses some distance of the ecliptic and, so, theoretically speaking, its

declination gets changed. It follows, therefore, that the East-West line in the above determination is not the true position of the actual East-West line. *Brahmagupta* (628 A. D.) was the first Hindu astronomer who prescribed the determination of the East-West line with proper allowance for the change in the Sun's declination. (Shukla) The details of the method intended by him have been supplied by his commentator *Prthūdaka Svāmī* (860 A. D.).

Bhāskara and Brahmagupta both give another method of determining directions : (*BrSpSi*. III. 2 ; *MBh*. III. 3) : With the three points (at the ends of the three shadows of the gnomon) corresponding to (any three) different times (in the day), draw two fish-figures (each with two of the three points) in accordance with the usual method. From the point of intersection of the lines passing through the mouth and tail (of the two fish-figures), determine the north and south directions. (*MBh*. III. 3).

Brahmagupta in his rule is more precise :

The point where the lines passing through the two fish-figures, which are drawn by means of three shadow ends (of the gnomon), intersect each other is for places in the northern hemisphere, the south direction, (if the midday shadow falls to the north of the foot of the gnomon). If the midday shadow falls towards the south of the foot of the gnomon, it is the north direction. (*BrSpSi*. III. 2).

This rule is obviously based on the assumption that the locus of the end of the shadow of the gnomon is a circle. In fact the locus for places whose latitude is less than $(90^\circ - \text{the obliquity of the ecliptic})$, this locus is a hyperbola.

Brahmagupta has made numerous uses of gnomon. He and Bhāskara, for example, both give the rules for finding the latitude and colatitude and the zenith distance and altitude of the Sun by finding out the length of the shadow and the length of the gnomon (*BrSpSi*. III. 10 ; *MBh*. III. 5) ; also rule for the determination of the latitude with the help of the Sun's meridian zenith distance and declination (*BrSpSi*. III. 13 ; *MBh*.

III. 17); also rule for finding the Sun's altitude (*BrSpSi*. III. 27; *MBh*. III. 24) (The Sun's altitude for the night has been called by Brahmagupta as *pātala-sanku*, *BrSpSi*. XV. 9).

Golayantra or Armillary Sphere

The first mention of the Golayantra or the armillary sphere is in the *Aryabhaṭya* (Golapāda. 22)¹ which was a uniformly round circle made of wood or of bamboo and which was of uniform weight or density alround. It was levelled with mercury, oil or water. A śalākā or pin (or rod) was fixed in it in the south-north direction. Its description from the commentary *Bhaṭṭadīpikā* of Paramādīśvara is given here :

A sphere of wood, uniformly round on all sides and with uniform density, and also light is made to revolve round an iron axis fixed north-south without friction (oil may be introduced to avoid friction). To the backside of the sphere, is fixed a *nālaka* full of water which has the length equal to the circumference of the sphere; and which has a hole at the bottom.

Now a thread, connected to the hook of the wooden ball (on the top side) passing over another small ball (in the same axis of the wooden ball) is attached to the mercury lobe by its other end. The mercury lobe is placed on the level of water and water is allowed to flow through the bottom hole and with water mercury lobe also goes down. The time in which the above hook of ball comes to bottom (180°) is noted.

The experiment is repeated with oil. The use of this mechanism is to revolve the ball by water or oil¹

1. काष्ठमयं समवृत्तं समन्ततस्सम गुरु लघुं गोलम् ।

पारतंतैलजलैस्तं भ्रमयेत्स्वधिया च कालसमम् ॥

Arya. IV. 22

काष्ठमयं वंशादि काष्ठेन निर्मितं समवृत्तं सर्वतोवृत्तं समन्ततस्सम गुरुं सर्वावयवेषु समं गुरुत्वं यथा भवति तथा कृतं । लघुमगुरुं यत् भूतं गोलं कृत्वा पारतादिभिस्तं स्वधिया च कालसमं भ्रमयेत् । अयमर्थः । भूमिष्ठ दक्षिणोत्तरस्तन्मयोरुपरि गोलप्रोतायश्शलाकाया अग्रे स्थापयेत् । गोलदक्षिणोत्तराच्छिद्रे च तैलेन सिञ्चेत् यथा निस्तङ्को गोलो भ्रमति । गोलस्यापरतो गोलपरिधिस्तमित दैर्घ्यं साधयिच्छद् जलपूर्णं नलकं निदध्यात् ततो गोलस्यापरस्वस्तिक कीलकं निधाय तस्मिन्सूत्रस्यैक मध्यं बद्ध्वादो विमुक्तमस्वल्लपृष्ठेन प्राङ्मुखं नीत्वा तदग्रबद्धं पारतपूर्णमलाह जलपूर्णे नलके निदध्यात् ततो नलकस्याध

[Cont. on Page 337]

In the Arabic epitome of the Almagest entitled *Tahriru'l mejesti*, the armillary sphere, *Za ul halk*, is thus described :

Two equal circles are placed at right angles, the one representing the ecliptic, the other the solstitial colure. Two pins pass through the poles of the ecliptic and two other pins are placed on the poles of the equator. On the first two pins are suspended a couple of circles moving, the one within, the other without, the first mentioned circles, and representing two secondaries of the ecliptic. On the two other pins a circle is placed, which encompasses the whole instrument, and within which the different circles turn; it represents the meridian. Within the inner secondary of the ecliptic, a circle is fitted to it, in the same plane and turning in it. This is adapted to measure latitudes. To this internal circle, two apertures or sights, opposite to each other, and without its plane are adapted like the sights of an instrument for altitudes. The armillary sphere is complete when consisting of these six circles. The ecliptic and secondaries are to be graduated as minutely as may be practicable. It is best to place both secondaries, as by some directed, within the ecliptic (instead of placing one of them without it), that the complete revolution of the outer secondary may not be obstructed by the pins at the poles of the equator. The meridian likewise should be doubled, or made to consist of two circles; the external one graduated and the internal one moving within it. Thus the pole may be adjusted at its proper elevation above the horizon of any place. The instrument so constructed consists of seven circles.

It is remarked that when the circle representing the meridian, is placed in the plane of the true meridian, so

श्चिद्द्रं विवृत्तं कुर्यात् तेन जलं निस्स्रवति । नलकस्य जलमधो गच्छति । तद्वशाच्च तदस्थमलावु
पारतपूर्यां गुरुत्वज्जलेन सहाधो गच्छद् गोलं प्रत्यङ्मुखमाकर्षति । एवं त्रिशद् घटिकाभिरर्धसंमितं यथा
जलं भवति गोलस्य चार्धं भ्रमति तथा स्वबुद्ध्या जलनिलावो योज्यः । इति ।

अमृतस्रावयोगेन कालभ्रमस्य साधनम् ।

गुणबीजसमाकृष्टं गोलयंत्रं प्रकल्पयेत् ॥

SaSi. XIII, 16-17

that it cuts the plane of the horizon at right angles, and one of the poles of the equator is elevated above the horizon conformably with the latitude of the place; then the motions of all the circles round the poles represent the motions of the universe.

After rectifying the meridian, if it be wished to observe the Sun and Moon together, the outer secondary of the ecliptic must be made to intersect the ecliptic at the Sun's place for that time: and the solstitial colure must be moved until the place of intersection be opposite to the Sun. Both circles are thus adjusted to their true places; or if any object but the Sun, be observed, the colure is turned until the object be seen in its proper place, on that secondary referred to the ecliptic: the circle representing the ecliptic being at the same time in the plane of the true ecliptic and in its proper situation. Afterwards, the inner secondary is turned towards the Moon (or to any star intended to be observed), and the smaller circle within it, bearing the two sights is turned, until the Moon, (or to any star intended to be observed), and the smaller circle within it bearing the two sights, is turned, until the Moon be seen in the line of the apertures. The intersection of the secondary circle and ecliptic is the place of the Moon in longitude: and the arc of the secondary, between the aperture and the ecliptic, is the latitude of the Moon on either side (North or South). (From Colebrooke's *Miscellaneous Essays*).

The same instrument, as described by Montucla from the text of Ptolemy (l. 3. c. 2) consists of six circles: first a large circle representing the meridian; next four circles united together, representing the equator, ecliptic and two colures, and turning within the first circle on the poles of the equator, lastly a circle turning on the poles of the ecliptic, furnished with sights and nearly touching, on its concave side, the circumference of the ecliptic.

The armillary sphere described by the Arabian epitomiser, differs, therefore, from Ptolemy's in omitting the equator and

equinoctial colure, and adding an inner secondary of the ecliptic, which as well as the meridian, is doubled.

According to Lalande, the astrolabe of Ptolemy, from which Tycho Brahe derived his equatorial armillary, consisted only of four circles: two placed at right angles to represent the ecliptic and solstitial colure; a third turning on the poles of the ecliptic and serving to mark longitudes; and a fourth, within the other three, furnished with sights to observe celestial objects and measure their latitudes and longitudes.

Whether the ancient Greeks had any more complicated instrument formed on similar principles, and applicable to astronomical observations, is perhaps uncertain. We have no detailed description of the instrument which Archimedes is said to have devised to represent the phenomena and motions of the heavenly bodies; nor any sufficient hint of its construction; nor does Cicero's account of the sphere exhibited by Posidonius suggest a distinct notion of its structure.

Among the Arabs, no addition is at present known to have been made to the armillary sphere; between the period when the *Almagest* was translated and the time of Alhazen, who wrote a treatise of optics, in which a more complicated instrument than that of Ptolemy, is described; Alhazen's armillary sphere is stated to have been the prototype of Tycho Brahe's; but neither the original treatise, nor the Latin translation of it, are procurable and one is therefore unable to ascertain whether the sphere, mentioned by the Arabian author, resembled that described by Indian astronomers. At all events, says Colebrooke, he is more modern than the oldest of the Hindu writers.

Here we give the literal translation of the passage on armillary sphere or *Golayantra* occurring in the *Sūrya-Siddhānta* :

Let the astronomer frame the surprising structure of the terrestial and celestial spheres.

Having caused a wooden globe to be made (of such size) as he pleases; to represent the Earth : with a staff for the axis passing through the centre, and exceeding the globe at both ends; let him place the supporting hooks, as also the equinoctial circle.

Three circles must be prepared, (divided for signs and degrees), the radius of which must agree with the

respective diurnal circles, in proportion to the equinoctial: the three circles should be placed for the Ram (*Meṣa*) and following signs, respectively, at the proper declination in degrees N. or S. ; the same answer contrariwise for the Crab (*Karkatā*) and other signs. In like manner three circles are placed in the southern hemisphere, for the Balance (*Tulā*) and the rest, and contrariwise for Capricorn (*Mṛga*) and remaining signs. Circles are similarly placed on both hoops for the asterisms in both hemispheres, as also for *Abhijit* and for the *Seven R̥sis*, *Agastya*, *Brahmahṛdaya* and other stars.

In the middle of all these circles is placed the equinoctial. At the intersection of that and supporting hoops, the distant from each other half the signs, the two equinoxes should be determined; and the two solstices, at the degrees of obliquity from the equinoctial; and the the places of the Ram (*Meṣa*) and the rest, in the order of the signs, should be adjusted by the strings of the curve. Another circle thus passing from equinox to equinox, is named the ecliptic; and by this path, the Sun illuminating worlds, for ever travels. The Moon and other planets are seen deviating from their nodes in the ecliptic to the extent of their respective greatest latitudes (within the zodiac).¹

1. भूलोकस्य रचनां कुर्यादश्वर्यकारिणीम् ।
 अभीष्टं पृथिवीगोत्रं कारयित्वा तु दारवम् ॥
 दण्डं तन्मध्यगं मेरोरुभयन्त्रं विनिर्गतम् ।
 आधारकक्ष्याद्वित्तं कक्ष्यां वैपुर्वतीं तथा ॥
 भगवांशुलैः कार्या दक्षितास्तिष्ठ एव ताः ।
 स्वाहोरात्रार्धकर्षैश्च तत्प्रमायानुपाततः ॥
 क्रान्तिविद्धोपसागैश्च दक्षिता दक्षिणोत्तरा ।
 स्वैस्त्वरपक्रमैः कार्या मेघादनामपक्रमात् ॥
 कक्ष्याः प्रकल्पयेत्ताश्च कक्ष्यादीनां विपर्ययात् ।
 तद्वत्तिष्ठस्तुलादीनां मृगादीनां विलोमतः ॥
 याम्यगोलाश्रिताः कुर्यात् कक्ष्यावारद्वयोपरि ।
 याम्योदग्भागं संस्थानां भानामभिजितस्तथा ॥
 सप्तर्षीणाङ्गस्यस्य ऋहमादीनां प्रकल्पयेत् ।
 मन्वे वैपुर्वती कक्ष्या सर्वसामेव संस्थिता ।

[Cont. on page 341]

The author of the *Sūrya-Siddhānta* then proceeds to notice the relation of the great circles before mentioned to the horizon, and observes that whatever place be assumed for the apex of the sphere, the middle of the heaven for that place is its horizon. He concludes by showing, that the instrument may be made to revolve with regularity, by means of a current of water; and hints, that the appearance of spontaneous motion may be given, by a concealed mechanism, for which quicksilver is to be employed. There is a hint of secrecy also in one of the lines, and it has, therefore, been stated that the construction and the mechanism of working should be learnt under the guidance of a teacher.

How to Observe Places of Stars

Details are not available in this connection. The *Sūrya-Siddhānta* only hints "that the astronomer should frame a sphere and examine the apparent longitude and latitude (*sphuṭavikṣepa* and *sphuṭadhruvaka*)". The commentators, however, describe the manner of making the observation. They direct a spherical instrument (*Golayantra*) to be constructed as described above. This instrument is very much similar to the armillary sphere. An additional circle graduated for degrees and minutes, is directed to be suspended on the pins of the axis as pivots. It is named as *Vedhavalaya* or intersecting circle, and appears to be a circle of declination. After noticing this addition to the instrument, the instructions proceed to the rectifying of the *Golayantra* or armillary sphere which is said to be placed, so that the axis shall point to the pole: and the horizon be true by a water level.

The instrument being thus placed, the observer is instructed to look at the star *Revati* through a sight fitted to an orifice at the centre of the sphere; and having found the star, to adjust by it the end of the sign Pisces on the ecliptic. The observer is then to look through the sight, at the *yoga* star of *Āśvini*, or at

तदाधारयुतेः भार्गमयने विपुवदये ।

अयनादयने चैव कक्ष्या तिर्यक्नथाऽपरा ॥

क्रान्तिसंज्ञा तथा सूर्यः सदा सदापर्येति भासयन् ।

चन्द्रायाश्च स्वरक्तैः पापैर्मण्डलमाश्रितैः ॥

ततोऽपकृष्टादृश्यन्ते विज्ञेयाग्रे ध्वपक्रमात् ।

SūSi. XIII. 3-12

some other proposed object; and to bring the moveable circle of declination over it. The distance in degrees, from the intersection of this circle and ecliptic, to the end of *Mina* or Pisces, is its longitude (*dhruvaka*) in degrees; and the number of degrees on the moveable circle of declination, from the same intersection to the place of the star, is its latitude (*vikṣepa*) North or South.

The commentators have rightly remarked that the 'latitude so found is *sphuṭa* or apparent, being the place intercepted between the star and the ecliptic, on a circle passing through the poles; but the true latitude (*asphuṭa*) is found on a circle hung upon the poles of the celestial sphere as directed in another place". (From Colebrooke's Paper on the Indian and Arabian Divisions of the Zodiac. *Miscellaneous Essays*, Vol. II, 324-326).

For the details of the *Golayantra*, readers are requested to refer to the description in the *Siddhānta-Siromaṇi* of Bhāskara II.



Reference

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अथ ब्राह्मस्फुट सिद्धान्तस्य

पूर्वादिशाध्याय्यां मध्यमाधिकारः

जयति प्रणतसुरासुरकिरीटरत्नप्रभाछुरितपादः ।
कर्ता जगदुत्पत्तिस्थितिविलयानां महादेवः ॥ १ ॥
ब्रह्मणोक्तं ग्रहगणितं महता कालेन यत् खिलीभूतम् ।
अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन ॥ २ ॥
ध्रुवताराप्रतिबद्धं ज्योतिश्चक्रं प्रतिक्षणगमादौ ।
पौष्णाश्विन्यन्तस्थैः सह ग्रहेर्ब्रह्मणा सृष्टम् ॥ ३ ॥
चैत्रसितादेरुदयाद्भानोदिनमासवर्षं युगकल्पाः ।
सृष्ट्यादौ लंकायां समं प्रवृत्ता दिनेऽर्कस्य ॥ ४ ॥
प्राणैर्विनाडिकाक्षी षड्भिर्घटिका विनाडिका षष्ठ्या ।
घटिका षष्ठ्या दिवसो दिवसानां त्रिशता मासाः ॥ ५ ॥

- ~~~~~
- (ग) १. श्री नमः ॥ परमात्मने । श्री रामाय सीतालक्ष्मणसहितायः ॥ श्री गुरुभ्यो नमः ॥ for (श्री.....मध्यमाधिकारः)
- (च) १. “ॐ नमः परमात्मने श्रीरामाय सीतालक्ष्मणसहिताय श्री गुरुभ्यो नमः । for (श्री.....मध्यमाधिकारः)”
३. (ग) १. पौष्णाश्विनांतरस्थैः for (पौष्णाश्विन्यन्तस्थैः)
- (च) १. पौष्णाश्विन्यंतरास्थैः for (पौष्णाश्विन्यन्तस्थैः)
४. (ग) १. दिन (च) for (दिन)
२. ऽर्कस्य for (ऽर्कस्य) (ख) दिनेर्कस्य for (दिनेर्कस्य)
- (क) श्लोक उपलब्ध नहीं
- (ख) ३. समप्रवृत्ता for (समं प्रवृत्ता)
- (च) ४. चित्र for (चैत्र) २. दिनेर्कस्य for (दिनेर्कस्य)
५. (क) श्लोक उपलब्ध नहीं ।

मासा द्वादशवर्षं विकलालिप्तांशराशिभगणांतः^२
 क्षेत्रविभागस्तुत्यः कालेन विनाडिकाद्येन^३ ॥ ६ ॥
 स्वचतुष्टय^१रदवेदा रविवर्षाणां चतुर्युगं भवति । ४३२००००^२
 सन्ध्या सन्ध्यांशै^३ सह चत्वारि पृथक्कृतादीनि ॥७॥
 युगदशभागो^१ गुणितः कृतं चतुर्भिस्त्रिभिर्गुणस्त्रेता ।
 द्विगुणो^४ द्वापरमेकेन संगुणः कलियुगं भवति ॥ ८ ॥
 १७२८०००१२६६०००१८३४०००१४३२०००
 युगपादानार्यभटश्चत्वारि समानि^२ कृतयुगादीनि । १००००००
 यदभिहितवान् न तेषां स्मृत्युक्तसमानमेकमपि ॥ ९ ॥

६. (ख) १. मास for (मासा)

२. भगणांत for (भगणांतः)

३. द्येवम् for (द्येन)

(च) २. भगणांताः for (भगणांतः)

७. (ग) १. स्वचतुष्टय for (स्वचतुष्टय) (क) (ख) (च)

(क) २, संख्या लुप्त है । टीका में उपलब्ध है ।

(ख) ३. संध्यांशैः for (सन्ध्यांशै)

८. (ग) १+१०+(च)

२+४+(च)

३+३+(क) गुणोत्रेता for (गुणस्त्रेता) (च) +३+

४+२+(च)

५ ८६४००० for (८३४०००) (क) टीका में उपलब्ध है । (च) ८६४०००

(क) संख्याएं लुप्त हैं, परन्तु टीका में दी हुई हैं । (ख)

९. (घ) १. नार्यः for (नार्य) (क) नार्यभट्ट for (नार्यभट)

(ग) २. समानिष्ट (ख) सभाति (च) समानिष्ट for (समानि)

(क) ३. संख्या लुप्त है ।

४. हितवान् for (हितवान् न)

५. समानामेकमपि (च) for (समानमेकमपि)

मनुरेक सप्तति^२युगः कल्पो^३ मनवश्चतुर्दश^४ मनूनाम् ।

आद्यंतरांतसंधिषु कृतकालोऽस्माद्युगसहस्रम् ॥ १० ॥

४३२०००००००

आद्यंतरातसंधिषु कल्पमनूनां^५ कृताब्दसमकालम् ।

नेच्छन्ति ये षड्भूतं^६ तेषां कल्पो युगसहस्रम् ॥ ११ ॥

४२६४००००००

मनुसंधियुगमिच्छत्यार्यभटस्तन्मनुर्यतस्त्वयुगः ।

कल्पश्चतुर्युगानां^७ सहस्रमष्टाधिकं^८ तस्य ॥ १२ ॥

४३५४५६००००

१०. (घ) २. ४३२००००००० for (४३२००००००००) (क) संख्या लुप्त है । टीका में अंकित है ।

(ग) २ + ७१ + (च)

३ कल्पो नवचतुर्दश १४ (च) for (कल्पोमनवश्चतुर्दश)

४ + १५ + (ख) कृतकल्पो for (कृतकालो) (च) + १५ +

(ख) ५. अद्यंतरांतसंधिषु for (आद्यंतरांतसंधिषु)

६. स्मुद्युगसहस्रम् for (स्माद्युगसहस्रम्)

११. (घ) १. भूतं for (षड्भूतं) (च) षड्भूतं for (षड्भूतं)

२. ४२६४०००००० for (४२६४०००००००) (क) संख्या लुप्त है

(क) ३. युगसहस्र for (युगसहस्रम्)

(ख) ४. अद्यंतरांत for (आद्यंतरांत)

५. कल्पमनूना for (कल्पमनूनां)

६. कृताब्दाः for (कृताब्द)

१२. (घ) १. (अस्पष्ट)

२. चतुर्युगाणां for (चतुर्युगानां)

(ग) ३. सहस्रमष्टाधिकं for (सहस्रमष्टाधिकं) (ख)

४. संख्या लुप्त है ।

(ख) ५. कृतमिच्छत्यार्यं for (युगमिच्छत्यार्यं)

६. कल्पाश्चतुर्युगाणां for (कल्पश्चतुर्युगानां)

(च) ७. + ७२ +

युगमन्वन्तरकल्पाः कालपरिच्छेदकाः स्मृतायुक्ताः ।
 यस्मान्न रोमके ते स्मृति बाह्यो रोमकस्तस्मात् ॥ १३ ॥
 कालर्क्षदेशयोगाद्बुधो ग्रहमन्दशीघ्रपातानाम् ।
 कल्पेन यतो योगस्ततः स्फुटं ग्रहयुगं कल्पः ॥ १४ ॥
 कल्पेर्जबुध सितानां भगणाः शून्यानि सप्तरवेदाः ।
 प्राग्व्रजता कुजगुरुशनिशीघ्रोच्चानां स्वकक्षासु ॥ १५ ॥
 ४३२०००००००

१३. (घ) १. न रोमके ते (च) न रौमुके ते for (न रोमके ते)

(ख) २. कलापरिच्छेदकाः for (कालपरिच्छेदकाः)

(च) ३. वि० इस प्रति में “.....परिच्छे” के पश्चात् लेखक ने भूल से फिर “मनुरेक सप्तति युग” से लिखना आरंभ कर दिया । इस प्रकार ५ $\frac{1}{3}$ पंक्तियां पुनः लिखी गईं ! उसके पश्चात् फिर क्रमशः लिखता गया ।

४. स्मृतबाह्यो for (स्मृतिबाह्यो)

१४. (घ) १. कालर्क्ष्य (ख) कालक्ष (च) कालर्क्ष्य for (कालर्क्ष)

२. द्वादभूयो (च) for (द्भूयो)

३. तत (च) for (ततः)

४. ग्रहयुगकल्पः (ग) ग्रहयुतं कल्पः for (ग्रहयुगं कल्पः)

(ग) ५. ग्रहशीघ्रमंद पातानां (क) (ख) for (ग्रहमन्द शीघ्रपातानां)

(च) ४. ग्रहयुग कल्पः for (ग्रहयुगं कल्पः)

१५. (घ) १. बुध (च) for (बुध)

२. व्रजनां (ग) व्रजती (ख) व्रजतां for (व्रजता)

(क) २. प्राग्व्रजतां for (प्राग्व्रजता)

३. संख्या लुप्त है । टीका में अंकित है ।

(ख) ४. भगणाः for (भगणाः)

५. सा for (सु) (च) स्व कक्षासु for (स्व कक्षासु)

पंचांबराणि गुणरामपंच सप्तस्वरेष्वः शशिनः ।

५७७५३३०००००

भौमस्य द्वियमशराष्ट्रपक्षवसुरत्नवद्वियमाः ॥ १६ ॥

२२६६८२८५२२

६३६६६८६८४

कृतवसुनवाष्ट्रनवनव षड्वनवागेन्दवो ज्ञशीघ्रस्य ।

१७६३६६६८६८४

जीवस्य शरेषूदधि षड्यक्षि द्विकृत्तरसरामाः ॥ १७ ॥

३६४२२६४५५

सितशीघ्रस्य यमलगो वेदनवाष्ट्राग्नि पक्षयमखनगाः ।

७०२२३८६४६२

अष्टनवपक्षमुनिरसशररसमनवोऽर्कयुत्रस्य ॥ १८ ॥

१४६५६७२६८

१६. (क) १. संख्या लुप्त है । टीका में अंकित है ।

२. संख्या लुप्त है । टीका में अंकित है ।

(ख) ३. पंच वाराणि for (पंचांबराणि)

४. गुणरामं for (गुणराम)

(च) ५. वृद्धि for (वद्वि)

१७. (घ) १. १७६३६६६८६८४ for (१७६३६६६८६८४) (च)

२. वागे (ग) षड्विनव (क) षट्त्रिं (ख) षट्त्रिंनवा for (षड्वनवागेन्दवो)

३. पद्यक्ष (ग) षट्द्व्यक्षि (क) षट्पक्ष (ख) षट्चक्ष for (षड्यक्षि)

(ग) ४. + २२६६८२८५२२ (क) 'ग' में अंकित संख्या १६वें श्लोक की टीका के अन्त में है ।

(क) ५. संख्या मूल में नहीं, टीका में अंकित है ।

६. संख्या मूल में नहीं, टीका में अंकित है ।

(ख) ७. वसू for (वसु)

(च) २. षड्वनवागेन्दवो for (षड्वनवागेन्दवो) ३ पद्यक्ष for (षड्यक्षि)

१८. (घ) १. लागो for (लगो) (च) यमलागो for (यमलगो)

२. यक्ष for (पक्ष)

३. ऽर्क (ग) ऽर्क for (ऽर्क)

(क) ४. मूल में संख्या लुप्त है । टीका में अंकित है ।

५, मूल में संख्या लुप्त है । टीका में अंकित है ।

(च) ६. चाष्टाग्नि for (वाष्टाग्नि)

खाष्टाब्धयो ४८० वसुशर वसुपंचखचन्द्रवसुवसुसमुद्राः ।

४८८१०५८५८

द्विनवयमा २६२ द्वित्रिगुणा ३३२ शरेषुवसव ८५५

स्त्रिपञ्चरसाः । १६ ॥ ६५३ ॥ १६ ॥

शशिवेदा ४१ मन्दानामर्कादीनां विलोमपातान्तम्

वसुरसरुद्रेन्द्रगुण द्वित्रियमा २३२३११६८ सप्तरसपक्षाः

२६७ ॥ २० ॥

१६. (घ) १. षष्ठौदधया (ग) खाष्टोदधयो for (खाष्टाब्धयो)

२. स्त्रिपंचसाः (च) स्त्रिपंचरसाः (स्त्रिपञ्चरसा)

(वि० चिह्नित संख्याएं यहां उपलब्ध नहीं हैं)

(ग) ४. द्विनवयमाः for (द्विनवयमा)

५. द्वित्रिगुणाः for (द्वित्रिगुणा)

(क) १. खाष्टोदधयो for (खाष्टाब्धयो)

६. + शशिवेदाः +

वि० श्लोकांकित कोई भी संख्या मूल में नहीं है। हाँ, टीका में विद्यमान है।

(ख) खाष्टोदधयो for (खाष्टाब्धयो)

(च) १. षष्ठौदधयो for (खाष्टाब्धयो)

७. संख्या लुप्त

८. संख्या लुप्त

९. शरेषुवस for (शरेषुवसव)

वि० श्लोकांकित संख्याएं लुप्त हैं।

२०. (घ) यहाँ श्लोक में निर्दिष्ट संख्याएं लुप्त हैं।

(ग) १. मर्कादीनां (क) चद्रादीनां (च) for (मर्कादीनां)

२. द्वित्रियमाः (क) (ख) द्वित्रियशः for (द्वित्रियमा)

(क) ३. संख्या लुप्त है, परन्तु टीका में अंकित है। (ख)

४. संख्या लुप्त है, परन्तु टीका में अंकित है। (ख)

(च) वि० श्लोकांकित संख्याएं लुप्त हैं।

२ द्वित्रियमाः for (द्वित्रियमा)

शशियमशरा ५२१^४ गुणरसा ६३ स्त्रिनन्दवसवः^३

८६३ समुद्रवसुविषयाः ५८४^५

चन्द्रादीनां पश्चात् ब्रजतोऽश्विन्यादिभगणस्य ॥ २१ ॥

परिवर्त्ता रवचतुष्टय शरादिधरसगुणायम द्विवसु

तिथयः । १५८२२३ । ६४५००००^१

रविभगणोना भान्तोः सावन दिवसाः कुदिवसास्ते ॥ २२ ॥

४३२०००००००

१५७७६१६४५००००

२१. (घ) १. ब्रजनोऽश्विन्यादि for (ब्रजतोऽश्विन्यादि)

२. (१६, २०, तथा २१ श्लोकों के अन्तर्गत आई हुई संख्याएं यहाँ एक ही स्थान पर दे दी गई हैं)

(ग) ३. स्त्रिनन्दवसव for (स्त्रिनन्दवसवः)

४. संख्या मूल में लुप्त हैं, परन्तु टीका में अंकित हैं ।

५. संख्या मूल में लुप्त हैं, परन्तु टीका में ५८५ अंकित हैं ।

(च) वि० श्लोकांकित संख्याएं लुप्त हैं ।

१. (१६, २०, तथा २१ वें श्लोकों के अन्तर्गत आई हुई संख्याएं यहाँ एक ही स्थान पर अंकित हैं यथा ४८०, ४८८१०५८५८ २६२ ३३२ ८५५ ६५३ ॥ ४१ : २३२३१११६८ २६७ ॥ ५२१, ६३ ८६३, ५८४ ।

२२. (घ) १. १५८२२३ ॥ ६४५०००० (च) १५८२२३ ॥ ६४५०००

२. सावा (ग) सा वा (ख) (च) दिवसां वा for (दिवसास्ते)

(ग) ३. परिवर्त्ताः (च) for (परिवर्त्ता)

४. यह संख्या यहाँ नहीं दी गई है ।

(क) ५. शरब्धि for (शराब्धि)

वि० मूल की तीनों संख्याएं लुप्त हैं, परन्तु टीका में क्रमशः अंकित हैं ।

रविभगणा रव्यब्दा द्वादशगुणिता भवन्ति रविमासाः ।

५१०४००००००

भगणांतरं रवीद्वोः शशिमासाः ५३४३३३०००००

सूर्यमासोनाः ॥ २३ ॥

अधिमासाः १५६३३००००० शशिमासास्त्रिंशद्गुणिता

१६०२६६६०००००० भवन्ति शशिविंशः ।

शशिसावनदिवसान्तरमवमानि तिथिः शशंकदिनम् ॥ २४ ॥

२५०८२५५०००

सावनमुदयादुदयो भानां चार्क्षं नृत्सरोर्काश्च ।

पितृदिवसाः शशिमासा दिव्यानि दिनानि रविभगणाः ॥ २५ ॥

२३. (घ) १. यह संख्या यहाँ श्लोक की समाप्ति के उपरान्त रक्खी गई है । (ग) (च)

(क) २. भगणांतर (च) for (भगणांतरं)

३. रवीद्वोः for (रवीद्वोः)

४. संख्या मूल में लुप्त है, परन्तु टीका में अंकित है ।

१. मूल में संख्या लुप्त है, परन्तु टीका में अंकित है ।

(च) ३. रविद्वोः for (रवीद्वोः)

(ख) “रविभगणरव्यब्दा द्वादशगुणिता भवन्ति ।

रविमासाः भगणांतरे रवीद्वोः शशिमासाः सूर्यमासो ना ॥ २३ ॥”

यह श्लोक अधिक है ।

(ङ) यह श्लोक अंकित है ।

२४. (घ) १. यह संख्या यहाँ पहली पंक्ति के समाप्त होने पर लिखी गई है (ग) (च)

२. २५०८२५५०००० for (२५०८२५५०००)

(क) मूल की तीनों संख्याएं लुप्त हैं, टीका में क्रमशः निम्नांकित हैं —

५३४३३०००००, १६०२६६६००००००, २५०८२५५००००

२५. (घ) १. सवन (च) for (सावन)

२. चार्क्ष्यं (ग) (क) वार्क्षं (ख) वक्षा for (चार्क्षं)

३. कर्ब्दः (ग) (क) (ख) कर्ब्दः for (कर्श्च)

(ग) ४. पितृदिवसा for (पितृदिवसाः)

(क) ५. द्रुदयं for (द्रुदयो)

(च) २. चार्क्ष्यं for (चार्क्षं) ३ कर्श्चः for (कर्श्च)

कल्प^१ परार्धमनवः^६ षट्कस्य^७ गताश्चतुर्यु^२गत्रिधनाः ।

त्रोणि कृतादीनि^५ कालो^३ गोगैकगुणाः^४ शकान्तेऽब्दाः^६ ॥ २६ ॥

१८५२८१६०००, ११६६४०००, ३१७६

[illegible]

२. द्यता (ग) वनः ११६६४०००० (क) घनः (ख) त्रिघनम् for (घनाः)

३. काले (ग) कले (क) कलौ (ख) कलेगौगैकगुरा: for (कालो गोगैकगुरा:)

४. गोगैः (ग) गोगैक गुराः ३१७६ for (नोगैकगुराः)

५. अतिरिक्त संख्या + ३८८८००० +

(ग) रु. १८५२४१६०० for (१८५२४१६०००)

७. गताश्चतुर्युग for (गताश्चतुर्युग)

5. $+3555000+$

(वि० — उपर्युक्त संख्याएं 'ग' में श्लोक के अन्तर्गत ही हैं)

(क) १. पराद्ध for (परार्ध)

६. जन्धः for (ज्वादाः) (ख) सकनृपांते ज्वादाः for (शकान्ते ज्वादाः)

वि० मूल में संख्याएं लुप्त हैं, टीका में क्रमशः हैं—

१०००००००००००००००००००, २७, १७२५०००, ३१२६०००,

₹ 48,000, 31/12/2020.

(ख) १. कल्पपरार्द्ध for (कल्पपरार्ध)

(च) १. पराद्धं ७, गताश्चतुर्द्युगत्रिघत for (गताश्चतुर्द्युगत्रिघनाः)

३. काले for (कालो) ४ गोमैः कमुगुः for (गोमैकमुगुः) ६ शकांतेज्ज्दाः for
शकांतेज्ज्दाः)

(घ) ग्रहनक्षत्रोत्पत्ति ब्रह्मदिनादौ दिनक्षये प्रलयः ।

यस्मात्कल्पस्तस्माद्ग्रहगणिते कल्पयाताब्दाः ॥ २७ ॥

(वि०) (यह श्लोक १६०२ ई० में प्रकाशित 'ब्राह्मस्फुट सिद्धान्त' में नहीं है। यह संस्करण क्रीस कालेज के प्रोफेसर महामहोपाध्याय सुधाकर द्विवेद्विभूत नूतन-तिलक समेत 'मैट्रिकल हाल प्रैस' में मुद्रित हुआ—ब्राह्मस्फुट सिद्धान्त के साथ इसमें ध्यानग्रहोपदेशाध्याय भी प्रकाशित है)

(वि०) यह श्लोक (ग) तथा (क) पांडुलिपियों में निम्नांकित पाठान्तरों के साथ उपलब्ध है—

(ग) १. ग्रहः for (ग्रह);

(क) २. +स्युः+

नवनगशशिनिकृतनवय^१ नगनन्देन्दवः^४

१६७२६४७१७६ शकनृपांते ॥

सार्धमतीव^४ मनुनां सन्धिभिराद्यन्तरान्तगतैः ॥ २७ ॥

अधिकः स्मृत्युक्तमनोरार्यभटोक्तश्चतुर्युगेन मनुः ।

अधिकं विशांश युतैस्त्रिभिर्युगैस्तस्तस्य कल्पगतम् ॥ २८ ॥

१८६१२७१६

कल्पगताब्दद्वादशघातश्चैत्रादिमासयुक्तोऽधः ।

युगितो युगाधिमासै रविमासाप्ताधिमासयुतः ॥ २९ ॥

२७. (घ) १. यमांगतांदेन्दव (ग) यमाग (ख) यमागनन्देदवः for (यनगनन्देन्दवः)

२. यह संख्या यहाँ श्लोक के अन्त में दी है, (ग)

(ग) ३. सार्धं प्रतीत (ख) सार्धमतीत (च) सार्द्धमतिव for (सार्धमतीव)

(क) १. यमागणंदेदवः for (यनगनन्देन्दवः)

२. यह संख्या मूल में लुप्त है । टीका में उपलब्ध है ।

(च) १. यमांगत for (यनगनन्) —“देन्दवः” उत्तरार्ध का आरंभ है

४. उत्तरार्ध का आरंभ—देदवः for (देदवः)

५. + शकनृपांते +

६. + १६७२६४७१७६ +

२८. (घ) १. युगैस्तस्य कल्पगतम् for (युगैस्तस्तस्य कल्पगतम्) (ग) (क) (ख)

(ग) २. विशांश (क) (विशांश)

३. १८६१२३१७६ for (१८६१२७१६)

(क) ३. यह संख्या मूल में लुप्त है, टीका में निम्नांकित है—१८६१२३७६

(ख) ४. अधिकस्मृत्युक्त for (अधिकः स्मृत्युक्त)

(च) ३. स्मृत्युक्त for (स्मृत्युक्त)

२९. (घ) १. ब्दा for (ब्द) (च) कल्पगताब्दा for (कल्पगताब्द)

२. घाता for (घातश्) (क)

(ग) ३. युताः (for युतः)

(क) ४. युक्तोऽधः । (ख) युक्तोष (च) युक्तोषः for (युक्तोऽधः)

(च) २. द्वादशघातश्चैत्रादि for (द्वादशघातश्चैत्रादि)

त्रिंशद्गुणस्तिथियुतः पृथग्गुणावमगुणो युगैर्दुदिनैः ।

भक्तफलावमोनोऽर्कसावनाहर्गणोऽर्कादिः ॥ ३० ॥

इष्टग्रहभगणगुणादहर्गणात् कल्पसावनद्युहुतात् ।

भगणादि फलं मध्यो लंकायां भास्करोदयिकः ॥ ३१ ॥

आनयति दिवसवारं स्मृत्यविरोधेन मध्यमानथवा ।

ब्राह्मादन्यैस्तन्त्रैरार्यभटाद्यैर्न कश्चिदपि ॥ ३२ ॥

जगति तमोभूतेऽस्मिन् सृष्ट्यादौ भास्करादिभिः स्पृष्टैः ।

यस्माद्दिनप्रवृत्तिं दिनं वारोऽर्कोदयात्तस्मात् ॥ ३३ ॥

३०. (घ) १. विमानो (च) for (वमोनो)
 २. सावनोः (ग) सावनो (क) सावनो (ख) (च) for (सावना)
 ३. हर्गणो (ग) (क) ऽहर्गणो (च) for (हर्गणो)
 (ग) ४. + ३० +
 ५. भक्तः (क) (ख) for (भक्त)
 ६. ऽर्कादि for (ऽर्कादिः)
 (क) ४. त्रिंशद् गुणास्तिथियुतः for (त्रिंशद्गुणस्तिथियुतः)
 (ख) ५. मगुणे for (भक्तफला)
 (च) ६. ऽर्क for (ऽर्क) ६ ऽर्कादिः for (ऽर्कादिः)
३१. (घ) १. भास्करोदयिकः । (ग) (च) for (भास्करोदयिकः)
 (ग) २. ववादहर्गणात् for (गुणादहर्गणात्)
 (क) १. भास्करोदयिकः for (भास्करोदयिकः)
 (ख) ३. इष्टग्रहभगणा for (इष्ट ग्रहभगणा)
 (च) ४. दर्गणात् for (दहर्गणात्)
 ५. युहुता for (द्युहुतात्)
३२. (ग) १. नं कश्चदपि for (नं कश्चिदपि) (क) (ख) नं for (नं)
 (क) २. ब्रह्मा (ख) for (ब्राह्मा)
३३. (घ) १. तसोभूते for (तमोभूते) (ख) तमोभूतो for (तमोभूते)
 २. सृष्टैः (ग) (क) (च) for (स्पृष्टैः)
 (ग) ३. दिनवारो (ख) for (दिनवारो)
 (ख) ४. ऽर्कोदयस्तस्मात् for (ऽर्कोदयात्तस्मात्)
 (च) १. तसोभूते for (तमोभूते) ३. दिनवारोर्का for (दिनवारोऽर्को)

लङ्कासमयाम्योत्तररेखायां भास्करोदये मध्याः ।

देशान्तरोनयुक्ता रेखा प्रागपरदेशेषु ॥ ३४ ॥

दिनवारादिः पश्चादुज्जयनी दक्षिणोत्तरायाः प्राक् ।

देशान्तरघटिकाभिः पश्चात्प्राक् भवति रव्युदयात् ॥ ३५ ॥

भूपरिधिः खखशरारेखा स्वाक्षान्तरांश संगुणिताः ।

५००००

भगणांश ३६० हुता फलकृतिहीनो देशान्तरस्य कृतिः ॥ ३६ ॥

शेषपदगुणभुक्तिभूपरिधि हुता कलादि लब्धमृणम् ।

उज्जयनी याम्योत्तर रेखायाः प्राग्धनं पश्चात् ॥ ३७ ॥

३४. (य) १. रेखायां for (रेखायां)

(ग) २. रेखा (क) (ख) for (रेखा)

३५. (घ) १. दक्षिणोत्तरायाः for (दक्षिणोत्तरायाः) (च)

२. प्राग्भवति (ग) (क) (च) for (प्राक्भवति)

३६. (घ) १. ५००० (ग) for (५००००)

२. 'हुता' से पूर्व दी गई ३६० की संख्या यहाँ 'हुता' के पश्चात् दी गई है ।
(ग) (ख) हल (च)

(ग) ३. हीना (क) (ख) for (हीनो)

(क) ४. परिधि for (परिधि)

५. संगुणिता for (संगुणिताः)

वि० श्लोकान्तर्गत संख्याएं लुप्त हैं । (ख)

(ख) ६. स्वाक्षान्तरांश for (स्वाक्षान्तरांश)

(च) ३. हीनो for (हीनो)

७. क्रमसंख्या लुप्त

३७. (घ) १. गुणा (ग) (क) (च) for (गुण)

२. परिधिताकलादि for (परिधि हुताकलादि)

(ग) ३. कलादिलब्धमृणम् for (कलादि लब्धमृणम्)

(क) ४. रेखाया for (रेखायाः)

५. प्राग्धनं धनं (ख) for (प्राग्धनं)

(च) ३. कलादिलब्धमृणं for (कलादिलब्धमृणम्)

मध्यग्रहे स्फुटे वा भूपरि^५हिहृतात्पदाद् गुणात् षष्ट्या^१ ।
 लब्धं घटिकाद्यथा कर्म तिथि^६ ऋण^४ धनं ग्रहवत् ॥ ३८ ॥
 कल्पगताब्दा गुणिता रूपाष्टजिनैर्नैर्वाग्निसतगैः

२४८१७७३६ ।

खरसनवभि^२ ६६०० भक्ता^४ दिनावमान्यंशकाः शेषाः ॥ ३९ ॥
 तद्विकगुणा^१ १० योगादधि^३स्त्रिशता धृताल्लब्धम् ।
 शेषास्तिथयः शुद्धिदिनानि विकलं दिनांशेभ्यः ॥ ४० ॥

३८. (घ) १. मध्ये (ग) (च) for (मध्य)

२. स्फुटे (च) for (स्फुटे)

(क) ३. 'घ' लुप्त है—'छूट गया' का चिह्न है, आगे 'थावा' है ।

४. मृण for (ऋण)

(ख) ५. भूपरिहृतात् for (भूपरिहिहृतात्)

६. तिथिषु for (तिथि)

(च) ७. +॥ ६ ॥

३९. (घ) १. जनैर्नैर्वाग्नि for (जिनैर्नैर्वाग्नि) (ग) जिनै २४२४८१

२. यह संख्या यहाँ 'भक्ता' के पश्चात् अंकित है ।

(ग) ३. सतनगैः ७७३६ (क) सतनगैः (ख) for (सतनगैः)

४. यहाँ 'भक्ता' से आगे ६६०० की संख्या है ।

(क) ५. मानांशकाः for (मान्यंशकाः)

(च) १. रूपाथजनैर्नैर्वाग्नि for (रूपाष्टजिनैर्नैर्वाग्नि)

४०. (घ) १. गुणाः for (गुणा १०) (ग) तद्विकगुणा १० ब्द for (तद्विकगुणा १०)

२. हृता (ग) (क) हृताल्लब्धां (ख) हृताल्लब्धम् for (धृताल्लब्धम्)

(ग) ३. दधिमासास्त्रिशता (क) (ख) दधिमासा for (दधिस्त्रिशता)

(क) १. तद्विकगुणाब्दयोगा for (तद्विकगुणा १० योगा)

(ख) १. तद्विकगुणाब्द for (तद्विकगुणा १०)

४. दिनानि for (दिनानि)

(च) १. तद्विकगुणाः for (तद्विकगुणा)

२. हृताल्लब्धं for (धृताल्लब्धं)

कल्पगताक्षदिनयुतेः सूर्याद्योऽब्दविधौ गताब्दभगणवधः ।
 कल्पाब्दभूतो गणादिमध्यमः सूर्यभगणान्ते ॥ ४१ ॥
 चैत्रसिताद्यास्तितयः शुद्धिविहीनाः पृथग्गुणा रुद्रैः ।
 अवमांशेभ्यो यमनवरस ६६२ गुणितेभ्यो विभक्तेभ्यः ॥ ४२ ॥
 स्वच्छेनफलयुता हृतास्त्रिखागैः ७६३ फलावमविहीनाः ।
 रविमेषादिद्युगणो मुनिहृत् शेषोऽब्दपत्यादिः ॥ ४३ ॥

४१. (घ) १. सूर्यो (च) for (सूर्या)

२. योगताब्द for (पोगताब्द) (ग) ऽब्दभगण (क) धियोऽब्दभगण for (धिपोगताब्दभगण)

(ग) ३. गताब्ददिनयुतैः for (गताक्षदिनयुतेः) (क) गताब्द for (गताक्ष)

४. हृतो (क) (ख) हृतो for (भूतो)

५. भगणादि (क) (ग) भगणादि for (गणादि)

(ख) ३. कल्पगताब्ददिनयुतेः for (कल्पगताक्षदिनयुतेः)

२. धिपोऽब्दभगणवधः for (धिपोगताब्द भगणवधः)

(च) ६. अवग्रहचिह्नलुप्त

४२. (घ) १. प्रथग्गुणा (च) for (पृथग्गुणा)

(ग) २. गुणिते विभक्तेभ्यः for (गुणितेभ्यो विभक्तेभ्यः)

(क—यहाँ के मूलपत्र उपलब्ध नहीं हैं)

(च) ३. रुद्रैः for (रुद्रैः)

४३. (घ) १. त्रिखगैः for (त्रिखागैः) (ख) हृतास्त्रिखागैः for (हृतास्त्रिखागैः)

२. ७०३ (ग) for (७६३)

३. फलावम for (फलावम)

४. मेषादि (ग) (च) for (मेषादि)

(ग) ५. स्वच्छेदेन ६६०० (ख) स्वच्छेदन for (स्वच्छेन)

(क) (क—यहाँ का मूलपत्र उपलब्ध नहीं है)

(ख) ६. मुनिहृत् for (मुनिहृत्)

(च) १. हृतास्त्रिखगैः for (हृतास्त्रिखागैः) ३ फलावमविहीनाः for (फलावमविहीनाः)

६. मुहृत् for (मुनिहृत्)

द्युगणात्सप्तत्यंशं^३ स्वनवाकांशाधिकं^१ १२६ विशोऽव्यांशाः ।
 मध्याः सूर्यबुधसिताः शीघ्रोच्चं^२ कुजगुरुशनीनाम् ॥ ४४ ॥
 त्रिगुणमवमाशेषं^३ विभजेद्गुणसप्तशशिः^५ १७३ ।
 पृथगधिकोऽर्को^४ रविगुणतिथ्यंशैः^५ संयुतश्चन्द्रः ॥ ४५ ॥
 एकादशल्लिप्तांशा^२ भौमः शरसप्तवसुभिर्दिन्दुयमैः ।
 कृतगुणितोऽथ द्युगणोशाः पञ्चरसैः^५ षट्क बुधशीघ्रम् ॥ ४६ ॥

४४. (ग) १. यहाँ '१२६' संख्या नहीं दी गई ।

(क) क—यहाँ का मूलपत्र उपलब्ध नहीं है ।

(ख) २. सिता for (सिताः)

(च) ३. सप्तत्यंशं for (सप्तत्यंशं) ४ विशोऽव्यांशाः for (विशोऽव्यांशाः)

४५. (घ) १. सप्तशशिराप्तांशैः (ग) सप्तशशिभिराप्तांशैः for (सप्तशशिः १७३)

(ग) २. भावशेषं (च) for (भावशेषं)

(क) (क—यहाँ का मूल पत्र उपलब्ध नहीं है ।

(ख) १. सप्तशशिभिराप्तांशैः for (सप्तशशिः १७३)

३. रविगुणतिथ्यंशैः for (रविगुणतिथ्यंशैः)

(च) १. सप्तशशिभिः for (सप्तशशिः १७३)

४. +सप्तांशैः +

५. 'ण' लुप्त

६. वर्का for (ऽर्को)

३. रविगुणतिथ्यंशैः for (रविगुणतिथ्यंशैः)

४६. (घ) १. गणांशाः for (गणोशाः) (ख) द्युगणांशाः for (द्युगणोशाः)

(ग) २. लिप्तांशाः (ख) लिप्ताशान् for (लिप्तांशाः)

३. ८७५ रिपुयमैः ॥ २१ ॥ for (रिन्दुयमैः)

४. गुणितो द्युगणोशाः for (गुणितोऽवद्युगणोशाः) (ख) कृतगुणितो for (कृतगुणितोऽथ)

५. रसैः ६५ (ख) रसैः (च) for (रसैः)

(क) (कि—यहाँ का मूलपत्र उपलब्ध नहीं है)

(च) ३. रिन्दुयमैः ११ for (रिन्दुयमैः)

१. द्युगणोशाः for (द्युगणोशाः)

द्युगरोषु^६ बधो^५ लिप्ताजीवः^५ कृतशरगुरोः^१ शरकालोनः^२ ॥
 भागकलाः^१ सितशीघ्रं^२ विषयैर्वसवो^३ द्विषष्ट्याष्टौ^३ ॥ ४७ ॥
 द्विगुणाः^१ कलाः^२ दिनगणस्तिथिरामेद्वे^३ कालं च^४ सूर्यसुतः^५ ।
 नवभिर्भागः^१ साग ११२१ खशून्यवेदैश्चन्द्रोच्चम्^५ ॥ ४८ ॥

४७. (ग) १. गुरोः (ख) (च) for (गुरोः)

२. कालोनः । ३५४ । ५ ॥ for (कालोनः) (ख) शरकालोनः for
 (शरकालोनः)

३. ष्टौ । ८।८। for (ष्टौ) (ख) द्विषष्ट्याष्टौ for (द्विषष्ट्याष्टौ)
 । ५।६२

(क) (कि—यहां का मूलपत्र उपलब्ध नहीं है ।

(ख) ४. शित for (सित)
 ५. विषयै for (विषयै)

(च) ६. द्युगरोषु for (द्युगरोषु) ३ द्विषष्ट्याष्टौ for (द्विषष्ट्याष्टौ)

४८. (घ) १. द्विगुणाः for (द्विगुणाः)

२. कला for (कलाः) (ख) कलादिनगणास् for (कलादिनगणास्) (च)
 कला for (कलाः)

३. द्वे कले । ३१५ । २ । for (द्वे काल)

४. सागर—for (साग ११२१) (यहां कोई संख्या नहीं दी गई है) (ख)
 सागर

५. + । ६ । १ । ४००४ । १० । +

(क) (क यहां का मूलपत्र उपलब्ध नहीं है)

(ख) ६. कले for (काल)
 ७. चन्द्रोच्चः for (चन्द्रोच्चम्)

(च) ८. + १११ +

भागो नन्दशशांकैः ११६८ शशिशून्य ८७५२१ स्वरयामै

२७।६४००४।०११

रविमंडलांतिकयुता मध्य भगणान्ति ३५६ काशेषाः ॥ ४६ ॥

पादार्द्ध विपाददिनै रात्र्यद्धास्तमयदिनदलौदयिकाः । ३१५ ।

ऊनीकृत्वा तिथयो देशान्तरनाडिकानयुताः ॥ ५० ॥

४६. (घ) १. यमैश्च शशिपातः (ग) यमैश्च ७७०१ शशिपातः for (यामै २७ । ६४००४।०११)

२. मव्या (ग) (ख) for (मध्य)

३. ३५८ for (३५६) (ग) यहां यह संख्या नहीं दी गई ।

(ग) ४. भोगानन्द for (भागोनन्द)

५. १६ for (११६८)

६. भगणान्तिका शेषाः for (भगणान्ति ३५६ का शेषाः)

(क) (क—यहां का मूलपत्र उपलब्ध नहीं है ।)

(ख) ७. सूर्य for (शून्य)

१. यमैश्च शशिपातः for (यामै २७ । ६४००४।०११)

(च) १. स्वरयामैश्च शशिपातः for (स्वरयामै)

३. ३५६ । ५ । for (३५६)

८. काः for (का)

५०. (ग) १. दलौदयिकाः for (दलौदयिकाः)

२. नाडिकोनयुताः for (नाडिकानयुताः) (ख) नाडिकेन for (नाडिकान)

(क) (कि - यहां का मूलपत्र उपलब्ध नहीं है)

(ख) १. दिनदलौदयिका for (दिनदलौदयिकाः)

कलिगतशुद्धिः प्राग्वच्छुक्राद्योब्धाधिपोक्षभगण वध्यतक्षितिजस्य ।
खत्रिचाष्ट रससप्त वसुरवाग्निवेदयुतात् ॥ ५१ ॥

४३०८७६८००००

बुधशीघ्रस्य खरवांबर रसनन्द दृष्टोष्ट वसुयमो दधिभिः ।

४२८८८६६००

खचतुष्टयमशरगुण शशिवेदैः ४३१३५२००००

सुरेन्द्रगुरोः ॥ ५२ ॥

५१. (घ) १. ब्दा for (क्ष) (ग) व्द भगणवधात् for (क्षभगणवध्यत) (ख) व्द for (क्ष)
२. वध्यत् for (वध्यत) (पहली पंक्ति का अन्तिम शब्द) (ख) वधात् for (वध्यत)
३. 'क्षितिजस्य' दूसरी पंक्ति का आरम्भिक पद । (ग) (ख)
४. खत्र (ग) खत्रयाष्ट (ख) खत्रयाष्ट for (खत्रिचाष्ट)

(ग) ५. रसप्त for (रससप्त)

(क) (क—यहाँ का मूलपत्र उपलब्ध नहीं है ।)

(ख) ६. शुधि for (शुद्धिः)

७. दधियो for (ब्धाधिपो)

(च) ७. छुक्राद्योब्धाधियो for (छुक्राद्योब्धाधिपो)

२. वध्यत् for (वध्यत)

४. खत्रचाष्ट for (खत्रिचाष्ट)

८. वैदयुतात् for (वेदयुतात्)

५२. (घ) १. रसनं दृष्टो (च) for (रसनन्द दृष्टो)

२. यह संख्या यहाँ श्लोक के अन्त में दी है । (ग) (च)

(ग) ३. नन्दाष्टाष्ट (क) (ख) नन्दाष्टा for (नन्ददृष्टोष्ट)

४. ४२८८८६६००० for (४२८८८६६००)

(क) ४. मूल में संख्या लुप्त है । टीका में ४२८८८६६००० अंकित है ।

२. मूल में संख्या लुप्त है, टीका में ४३१३५२००० अंकित है ।

भार्गव^१शीघ्रस्यांबर खखाष्टं वेदा^३ब्धि^५वेदखाग्नि^६ कृतैः ४३०४४४०००
भास्कर सुतस्य खत्रय रविगुणशरखगुण समुद्रैः ॥ ५३ ॥

४३०५३१२०००

शून्यचतुष्टय^७ पक्षेदु^२ रामगुण^६ नवभिरर्कमंदस्य । ६३३१२००००
इन्दोः खमय यमशरनव पंचव्योम शरचन्द्रैः ॥ ५४ ॥ १५०५६२०००
खत्रय यमनवपंचाष्टरामधूतिभिः शशांकपातस्य । १८३८५६२०००
कल्पगतभरणघातात् कुजादिमंदोच्चपातानाम् ॥ ५५ ॥

५३. (घ) १. भाग्नव (च) for (भार्गव)

२. शरखद for (शरखगुण) (ख) शरखदहन समुद्रैः for (शरखगुणसमुद्रैः)

(ग) ३. खखाष्ट for (खखाष्टं) (क) (ख) खखाष्ट for (खखाष्टं)

४. दहनसमुद्रैः (क) for (खगुणसमुद्रैः)

(ख) ५. वेदाश्च for (वेदाब्धि)

६. वेदखाब्धि for (वेदखाग्नि)

७. भागस्कर for (भास्कर)

(च) ३. खखाष्ट for (खखाष्टं)

४. खद for (रविगुण)

५४. (घ) १. त्रयं for (खमय) (ख) त्रयमशर for (खमययमशर) (च) खत्रये for (खमय)

(ग) २. पक्षेन्दु (क) (च) for (पक्षेदु)

३. चन्द्रमसः शून्यत्रय for (इन्दोः खमय)

४. यमशनवशरखशरचन्द्रैः for (यमशरनवपंचव्योम शरचन्द्रैः)

५. १५०५६५२००० (च) for (१५०५६२०००)

(क) ३. चन्द्रमसः शून्यत्रय for (इन्दोः खमय)

६. शरख for (पंचव्योम)

वि० मूलांकित दोनों संख्याएँ मूल में नहीं हैं। टीका में अंकित हैं।

(ख) ७. शून्य for (शून्य)

५५. (क) मूल में संख्या उपलब्ध नहीं। टीका में अंकित है।

(ख) १. गणोध्ययातात्कुंजादि for (गणघातात् कुजादि)

भगणादिकल्पवर्षे^५ लब्धं^१ रविमंडलान्तिकामध्या^६ ।

मेषादिद्युगुण^३फलाधिका भवन्तीष्टदिनमध्याः ॥ ५६ ॥

शुद्धीश ११ बधे शुद्धे^१ देवमशेषात् सावनद्युगुण शुद्धिः^४ ।

व्येकावमं^२ गृहीत्वा गुणस्वमुने युतान्^५ शुध्यति^६ चेत् ॥ ५७ ॥

५६. (घ) १. लब्धम् for (लब्धं) (ग) (क) (ख) लब्ध for (लब्धं)

२. मेषादि for (मेषादि)

३. द्युगुण (ग) (क) for (द्युगुण)

(क) ४. मध्याः (ख) मध्यः (च) मध्य for (मध्या)

(ख) ५. वर्षैः for (वर्षे)

६. लान्तिको for (लान्तिका)

(च) १. ब्धं for (लब्धं) ३ क (द्यु) गुण for (द्युगुण)

५७. (घ) १. शुद्धेज्वशेषा (ग) शुद्धेज्वमशेषात् (ख) शुद्धेवमशेषात् for (शुद्धेदेवमशेषात्)

२. व्येकामवं (ख) एकावमं for (व्येकावमं)

३. खमुने (क) खमुनि for (स्वमुने)

(ग) शुद्धीश के पश्चात् ११ की संख्या नहीं दी गई है । (क)

(क) १. ज्वमशेषोत्सावन for (देवमशेषात्सावन)

४. सिद्धिः (ख) सुद्धिः for (शुद्धिः)

(ख) ५. युतानि for (युतान्न)

६. सुध्यति for (शुध्यति)

(च) १. शुद्धेज्वमशेषात् for (शुद्धेदेवमशेषात्)

२. व्येकामवं for (व्येकावमं)

चैत्रसिताद्योब्द पतिद्वूनाया दिनाब्दरूपयुतेः ।
 तद्युगणादिनवारान् मुहुर्मध्यमा प्राग्वत् ॥ ५८ ॥
 अक्रतार्यभटः शीघ्रगमिन्दुच्चं पातमल्पगं स्वगतेः ।
 तिथ्यन्तग्रहाणानां घृणाक्षरं तस्य संवादः ॥ ५९ ॥

५८. (घ) १. शुद्धचूनाया for (पतिद्वूनाया) (ग) (क) पतिः शुद्धचूनाया for (पतिद्वूनाया)
 २. वारान् (ग) वारः (क) वारः (ख) वारः for (वारान्)
 ३. मध्यमा (ग) (क) मध्यमा for (मध्यमा)
 ४. मुहूर्त्त (शुद्धचू) (ग) शुद्धचूना (क) शुद्धचवमा for (मुहुर्मध्यमा)
 (ग) ५. चैत्रसिताद्योब्दपतिः for (चैत्रसिताद्योब्दपति)
 (क) ६. तद्युगणात् for (तद्युगणा)
 (ख) १. पतिः शुद्धचूनाया for (पतिद्वूनाया)
 ४. शुद्धचूना for (मुहुर्मध्यमा)
 (च) १. पतिः शुद्धचूनाया for (पतिद्वूनाया)
 ६. तत् युगणा for (तद्युगणा)
 ३. मध्यमाः for (मध्यमा)
५९. (घ) १. स्वगतैः (ख) स्वगते for (स्वगतेः)
 २. घृणाक्षरं (च) for (घृणाक्षरं)
 (ग) ३. दूच्चं (क) (ख) दूषं for (दुच्चं)
 (क) ४. ग्रहाणानां (ख) (च) for (ग्रहाणानां)
 ५. मल्पगं for (मल्पगं)
 ६. 'संवादः' पद लुप्त है ! श्लोक तो 'तस्य' पर समाप्त है ।
 (च) ७. शिघ्र for (शीघ्र)

(घ) खखखार्क १२००० हृताब्देभ्यो, गतगम्याल्पाः खसून्ययमल २०० हृताः ।
 लब्धं त्रि ३ सायक ५ हतं कलाभिरूनौ सदाकैन्द ॥ ५९ ॥
 शशिवत् जीवे द्वि २ हतं, चन्द्रोच्चे तिथि १५ हतं तु सितशीघ्रे ।
 द्वीषु ५२ हतं च बुधोच्चे, द्वि २ कु १ वेद ४ हतं च पात कुजस्रनिषु ॥ ६०
 वि० उपर्युक्त दोनों श्लोक १६०२ ई० में प्रकाशित ब्राह्मस्फुटसिद्धान्त में
 "अतिरिक्त" हैं ।

मध्यगतिज्ञं वीक्ष्य श्री षेणार्यभटविष्णुचन्द्रज्ञाः ।
 सदसि न भवन्त्यभिमुखाः सिंहं दृष्ट्वा यथा हरिणाः ॥ ६० ॥
 युगभरणमान याताहर्गण दिनवारमध्यमाद्येषु ।
 मध्यमगति द्विषष्टचार्याणां प्रथमकृतो है ॥ ६१ ॥

६०. (ग) १. वीक्ष for (वीक्ष्य)
 २. द्विष्टा for (दृष्ट्वा)
 (क) ३. श्रीहर्षेणार्य for (श्रीषेणार्य)
 (ख) ५. विभुचन्द्राद्या for (विष्णुचन्द्रज्ञाः)
 ६. हरिणः for (हरिणाः)
६१. (घ) १. हर्गण for (हर्गण)
 २. द्विषष्टचार्याणां (ग) द्विषष्टचार्या (क) द्विषष्टार्याणां for (द्विषष्टचार्याणां)
 ३. प्रथमः कृतोऽध्यायः (ग) (क) प्रथमाः for (प्रथमकृतो है)
 (ग) वि० + इति श्री ब्रह्मसिद्धांते मध्यमाधिकारः प्रथमः +
 (ख) ५. यतो for (याता)
 २. द्विषष्टार्याणां for (द्विषष्टचार्याणां)
 (ख) की दृष्टि से ६३ श्लोक है, २३ वां अधिक है ।
 (च) ३. प्रथमः for (प्रथम)
 ४. कृतोऽध्यायः for (कृतो है)

॥ श्रीगणेशायनमः ॥

यस्मान्न मध्यतुल्यः प्रतिदिवसं दृश्यते ग्रहो भगरो ।

तस्माद् कल्पकरं वक्ष्ये मध्यस्फुटकरणम् ॥ १ ॥

अर्धज्याभूयमला मुनियमवेदा वसुज्जलषट्का ।

रसकृतवसवः शशिपंचखेन्दवश्चन्द्रशरसूर्याः ॥ २ ॥

षट्दधिमनवो भूवाग्निरसशशांका मुनीदवसुचन्द्राः ।

इन्दुनवनन्दचन्द्रा रसतिथय यमला रवित्रियमाः ॥ ३ ॥

१. (घ) १. तस्माद् for (तस्माद्) (ग) तस्माद्क् तुल्यकरं (क) तस्माद्क् तुल्यकरं for (तस्माद्कल्पकरम्)
२. स्फुटं for (स्फुट) (ग) स्फुटीकरणम् (क) स्फुटीकरणम् for (स्फुटकरणम्)
- (ग) ३. वक्ष्ये for (वक्ष्ये)
- (क) ४. मध्यम for (मध्य)
- (ख) १. तस्माद्क् तुल्यकरं for (तस्माद् कल्पकरं)
२. स्फुटीकरणम् for (स्फुटकरणम्)
- (च) ५. “मंगलसूचक शब्द” लुप्त है !
१. तस्मात् इ for (तस्माद्) २ स्फुटं for (स्फुट)
२. (घ) १. मनुयमला for (भूयमला (ग) (क) अर्धज्यामनुयमला for (अर्धज्या-भूयमला)
२. वसुज्जलषट्काः (ग) (क) वसुज्जलनषट्काः for (वसुज्जलषट्का)
- (ख) १. अर्धज्यामनुयमला for (अर्धज्याभूयमला)
२. वसुज्जलनषट्काः for (वसुज्जलषट्का)
३. चन्द्रमसूर्या for (चन्द्रशरसूर्याः)
- (च) १. अर्धज्यामनुयमला for (अर्धज्याभूयमला)
२. वसुज्जलनषट्काः for (वसुज्जलषट्का)
३. (घ) १. तिथिय for (तिथय) (ग) (क) रसतिथि (ख) रसतिथि for (रसतिथय)
२. यम्नाः for (यमाः) (ख) for (यमाः)
- (ग) ३. भूताग्नि (क) (ख) (च) for (भूवाग्नि)
४. मुनीदु (क) (ख) (च) for (मुनीद)
- (क) ५. षडवब्धि for (षट्दधि)
६. चन्द्रा for (चन्द्राः)
- (ख) ७. चन्द्राः for (चन्द्रा) (च) १. तिथि for (तिथय)

ऋतुनवखगुणाः^३ नवशरचन्द्रगुणाः^१ सप्तशून्ययमदहनाः^४ ।

द्विजिनगुणा^५ स्त्रिरसरदा^५ खस प्रयम छिद्रेषु^६ जिनाः^७ ॥ ४ ॥

४ (घ) १. चन्द्रागुणा (च) for (चन्द्रगुणाः)

२. सप्त for (सप्त) (ग) सप्तयम वल्लयो व्यस्ताः ॥ ५ ॥ for (सप्रयम-
छिद्रेषु जिनाः ॥ ४ ॥)

(ग) ३. गुणा for (गुणः)

४. दहनाः for (दहना)

५. रदाः for (रदा)

(क) 'क' में अंकित नहीं। इसके स्थान में दूसरा श्लोक अंकित है जो अगले पृष्ठ पर दिया है।

(ख) यहां यह श्लोक अंकित नहीं है।

(च) २. सप्त for (सप्त)

६. छिद्रेषु for (छिद्रेषु)

७. क्रमसंख्या लुप्त ।

(क. ख. ग.) में अतिरिक्त श्लोक —

छिद्रेषु जिना^१ कृतनव^२ पंचयमा दं नंद चन्द्रमुनि पक्षाः ।

दन्ताष्टयमागुण^५ रामनवयमाः^६ शशिख^३ रामाः ॥ ४ ॥

ऋतुनव खगुणा नवशरचंद्रगुणाः सप्तशून्ययमदहनाः ।

द्विजिन^४ गुणास्त्रिरसरदाः^५ खसप्तयम वल्लयो व्यस्ताः^७ ॥ ५ ॥

(क) १. यमाः for (यमा)

२. 'दं' लुप्त पद है। (ख)

३. शशियमखरामाः ॥ ४ ॥ (ख) शशिगुणखराम for (शशिखरामाः)

४. जित for (जिन)

(ख) ५. दताष्ट for (दन्ताष्ट)

६. यमगुण for (यमागुण)

७. व्यास्ताः for (व्यस्ताः)

(च) वि० इस स्थान पर यह श्लोक लुप्त है।

पृष्ठ ८b पर नीचे की ओर अन्य लेख में “ऋतुनव.....से-खसप्रयम” तक विद्यमान है। इस पर क्रम संख्या कोई नहीं।

कृतनव पंचयमा^२ नन्द चन्द्र^३ दन्ताष्ट^१ यमगुण^१ रामनवयमा^४ ।
 शशियम खरामा^५ मुनिपक्षा^५ वल्लयो^५ व्यस्ताः ॥ ५ ॥
 मुनयोष्टयमास्त्रिरसा^५ रुद्र शशांकाः^२ समुद्रमुनिचन्द्राः ।
 नववेदयमामुनिगुणा^३ हुताशना^३ वसुगुणसमुद्राः ॥ ६ ॥
 रूपेन्द्रियेष्वोरसनगर्तवश्चन्द्रशीतकरवसवः ।
 वसुशरनन्दाः^३ सागररुद्रशशांकाः^२ नवागार्काः^४ ॥ ७ ॥
 त्रिविषयवेदशशांकाः^२ पंचत्रिरसद्वोद्धियमधृतयः ।
 अतिधृतिस्वयमानवशशियमपक्षा^३ सागर द्विजिना^१ ॥ ८ ॥

५. (घ) १. यमा (च) for (यम)

(ग) वि० यहां चौथे और पांचवें श्लोक की चारों पंक्तियों को कुछ भिन्न प्रकार से लिखा है । (क)

(क) १. क + षट् छिद्रेषु जिना २४५६ +

२. यमाः + २५६४ + for (यमा)

३. चन्द्रमुनिपक्षाः २७१६ for (चन्द्रदन्ताष्ट)

१. यमाः + २८३२ for (यम) । इसके पश्चात् दूसरी पंक्ति प्रारम्भ

४. + २६३३ +

५. + ३०२१ +

(ख) यहां पर यह श्लोक 'लुप्त' है ।

६. (ग) ३. गुण (च) for (गुणा)

(क) ४. रुद्राः for (रुद्र)

(च) २. कुताशना for (हुताशना)

७. (घ) १. त्वंश्चन्द्र for (तवश्चन्द्र)

(क) २. शशांका (च) for (शशांकाः)

(ख) ३. नन्दा for (नन्दाः)

४. नवागार्का for (नवागार्काः)

८. (घ) १. द्विजिनाः (ग) (च) for (द्विजिनाः)

२. ख (क) (च) for (स्व)

(ग) ३. पक्षाः (क) for (पक्षा)

(ख) ४. भि for (त्रि)

(वि० देखिए पृष्ठ २६—सारणी के लिए)

रदरसयमला गुणवेदवसुयमाः षट्क विषयशून्यगुणाः ।

खमुनिरसा व्यासाद्ध^१ नवरदचन्द्रा जिनांशय्याः ॥ ६ ॥ २४।१३।२६

२१४	^१ १८८७	२६३३	७	५५१	१८२४
४२७	१६६१	३०२१	२८	६७६	२०१६
६३८	२१५६	३०६६	६३	८११	२२१६
८४६	२३१२	३१५६	१११	६५८	२४२४
१०५१	२४५६	३२०७	१७४	१११४	२६७२ ^३
१२५१	२५६४	३२४२	२४६	१२७६	२८४३
१४४६	^२ २७१४	३२६३	३३७	१४५३	३०५६
१६३५	२८३२	३२७०	४३८	१६३५	३२७०

६. (घ) १. रदा (ग) रदा (क) (च) for (रसा)

२. २४ ॥ १३२६ for (२४।१३।२६) ॥ (ग) १३२६ + ॥ २१४ ॥ ४२७
 ॥ ६३८ ॥ ८४६ ॥ १०५१ ॥ १२५१ ॥ १४४६ ॥ १६३५ ॥ १८२४ ॥
 ॥ १६६१ ॥ २१५६ ॥ २३१२ ॥ २४५६ ॥ २५६४ ॥ २७१४ ॥
 ॥ २८३२ ॥ २९३३ ॥ ३०२१ ॥ ३०६६ ॥ ३१५६ ॥ ३२०७ ॥ ३२४२ ॥
 ॥ ३२६३ ॥ ३२७० ॥ एतेक्रमस्थाः ॥ अत उत्क्रमस्थाः ॥ ७ ॥ २८ ॥
 ॥ ६३ ॥ १११ ॥ १७४ ॥ २४६ ॥ ३३७ ॥ ४३८ ॥ ५५१ ॥ ६७६ ॥ ८११ ॥
 ॥ ९५८ ॥ १११४ ॥ १२७६ ॥ १४५३ ॥ १६३५ ॥ १८२४ ॥ २०१६ ॥
 ॥ २२१६ ॥ २४२४ ॥ २६३३ ॥ २८४३ ॥ ३०५६ ॥ ३२७० ॥ उत्क्रमज्या
 इति ॥ +

(ख) ४. जिनांशय्या for (जिनांशय्याः)

(सारणी) (घ) १. १८१७ (ग) (च) for (१८८७)

२. २७१६ (ग) (च) for (२७१४)

३. २६३२ (ग) (च) for (२६७२)

(क) यहाँ यह सब लुप्त हैं ।

लिप्तास्तत्त्वयमहृता २२५ लब्धं द्याष्टृचांतराहृता छेषात् ।
 तिथिकृति २२५ हृत्फलयुता लब्धषष्ट्या द्वा ग्रहणमेवम् ॥ १० ॥
 ज्यां प्रोह्य शेषगुणितास्तत्त्वयमा ज्यांतरा धृतालब्धम् ।
 क्षेप्यं विशुद्धजीवासंख्यातिथि कृतिवधे चापम् ॥ ११ ॥

१०. (घ) १. ज्याष्टृचांतरा (ग) ज्याज्यांतरा (क) ज्याज्यांतरा (च) for (द्याष्टृचांतरा)
 २. हृतात् (क) for (हृत्)
 ३. ष्ट्या (ग) ज्या (क) (ख) षष्ट for (षष्ट्या)
 ४. ज्या (ग) ज्या (क) (ख) ज्या for (द्वा)

- (ग) ५. मलहृता (ख) यमाहृता for (यमहृता)
 ६. २२५ हृतात्फल for (हृत्फल)
 ७. लब्धं for (लब्ध)

- (क) २. हृतात्फलयुतात् for (हृत्फलयुता)

- (ख) १. लब्धद्याष्टृचां for (लब्धद्याष्टृचां)
 ८. ग्रहणमेव for (ग्रहणमेवम्)

- (च) ६. २., २२५ हृतात्फलयुता for (२२५ हृत्फलयुता)
 ३. ष्ट्या for (षष्ट्या)
 ४. द्वा for (द्वा)

११. (घ) १. ज्यांतरो (क) ज्यांतरोद्धृता (च) ज्यांतरोधृता for (ज्यांतराधृता)
 २. संख्या for (संख्या)

- (ग) ३. गुणितास्तत्त्वयमा २२५ for (गुणितास्तत्त्वयमा)
 ४. +न+
 ५. +२२५+

- (क) ६. सेष (ख) सेष for (शेष)

- (ख) ७. प्रयोज्यय for (प्रोह्य)
 ८. क्षेपं for (क्षेप्यं)

- (च) ७. प्रोज्य for (प्रोह्य) ८. क्षेप्यं for (क्षेप्यं)

मध्याद्विशोध्य मंदं शीघ्रात्संशोध्य मध्यमं केन्द्रम् ।
 अयुतिगता यथा यो^३ युति पदेऽन्यथा बाहुकोटिज्ये ॥ १२ ॥
 त्रिज्याहता भुजज्या २२७० युगयुक्परिधि द्व्यांतर गुणात्प्या ।
 युग्मांतर परिधिरधिको हीनोऽधिकः हीनोधिकः स्पष्टः ॥ १३ ॥
 तद्गुणितेज्ये भांशैः ३६२ हूते फले कोटिफलयुता त्रिज्या ३२७० ।
 आद्यन्तयोर्निहीनो पदयोर्द्वितृतीययोः कोटिः ॥ १४ ॥

१२. (घ) १. व्ययुगगतयेयोर्युजि (ग) अयुजिगतयेयोर्युजि for (अयुतिगताययायो युति)

(क) १. अयुजिगतैर्योज्ययोर्युजि for (अयुतिगताययायोर्युति)

(च) १. अयुतिगतं for (अयुतिगता) २ या for (यो) ३ युति for (युति)

४. अवग्रहचिह्नलुप्त

१३. (घ) १. द्व्यांतर (ग) द्व्यांर (क) द्व्यांतर (ख) द्वध्व्यांतर for (द्व्यांतर)

२. गुणात्प्या (ग) गुणाप्प्या for (गुणात्प्या)

३. परिधिको हीनो हीनाधिकः for (परिधिरधिको हीनोऽधिकः हीनोऽधिकः)

(ग) ४. ३२७० हता (क) त्रिज्याहता (च) for (त्रिज्याहता)

५. यह संख्या अंकित नहीं ।

६. 'अधिकः' शब्द अंकित नहीं (क)

(क) ७. 'युग्मांतर for (युग्मांतर)

(ख) ६. 'हीनोऽधिकः' पद लुप्त हैं

८. हीनाधिकः for (हीनोधिकः)

(च) ५. २७७० for (२२७०) २ + ८ +

३. परिधिकोहीनो for (परिधिरधिको हीनोऽधिकः)

१४. (घ) १. विहीना (ग) विहीना (क) विहीना for (निहीनो)

(ग) २. हूते (क) for (हूते)

३. द्वितृतीययोः for (द्वितृतीययोः)

(ख) १. विहीनो for (निहीनो)

(च) १. विहीना for (निहीनो)

तद्भुजफल^१ कृतियोगान्मूलं^२ कर्णः^३ पदेष्वयुग्युक्षु^४ ।
 स्वपरिधिगुणा^५ क्रमोत्क्रमजीवा^६ भांशे^७ ३६० हृतात्मन्दे^८ ॥ १५ ॥
 क्षयधनधनक्षयास्तत्फलानि^९ शीघ्रेऽन्यथा^{१०} धनं^{११} धनयोः ।
 ऋणमृणयोर्योगान्तरमृणधनयोस्तुल्ययोः^{१२} शन्यं^{१३} ॥ १६ ॥
 तच्चापं^{१४} मन्दफलं^{१५} फलयोगान्तरवशाद्धनमृणं^{१६} वा ।
 शीघ्रफलं^{१७} तद्गुणिताद्वासाद्धात्^{१८} कर्णलब्धधनुः^{१९} ॥ १७ ॥ ३२७०
 देशान्तरे^{२०} खमध्ये^{२१} भुजफलचापे^{२२} भुजांतरे^{२३} च कृते ।
 उन्मण्डलेऽर्कं^{२४} चन्द्रौ^{२५} स्पष्टौ^{२६} रविचरदले^{२७} क्षितिजे^{२८} ॥ १८ ॥
 अर्कोदयास्तमययोर्विना^{२९} चराद्धेन^{३०} रात्रिदिनदलयोः ।
 न स्फुटमार्यभटोक्तं^{३१} स्पष्टीकरणं^{३२} स्फुटोक्तिरतः^{३३} ॥ १९ ॥

१५. (घ) १. कर्णं पदेष्वयुग्युक्षुः for (कर्णः पदेष्वयुग्युक्षुः)
 २. गुणाः (च) for (गुणाः)
 ३. म्यांशे for (भांशे ३६०) (ग) हृताफलं मंदे for (हृतात्मन्दे)
 ४. मांदैः (क) हृतामांदो (ख) हृतात्मन्दे for (हृतात्मन्दे)
 (क) ५. पदेष्वयुक् युक् स्यात् for (पदेष्वयुग्युक्षुः)
 (ख) ६. क्रमोत्क्रमजीवा for (क्रमोत्क्रमजीवा)
 (च) १. कर्णपदेष्वयुक्षुः for (कर्णः पदेष्वयुग्युक्षुः)
 ३. ज्यां (भां) शै for (भांशे) ४. हृतामंदै for (हृतात्मन्दे)
 १६. (घ) १. धनयोः for (धनयोस्)
 (ग) २. योगान्तर for (योगान्तर)
 ३. तुल्ययो for (तुल्ययोः)
 १७. (घ) १. गुणिता for (गुणिताद्)
 (ग) २. व्यासाद्धात् (क) व्यासोद्धात् for (व्यासाद्धात्)
 (क) ३. मृणंवति for (मृणंवा)
 (च) १. तद्गुणितोद् for (तद्गुणिताद्)
 १८. (घ) १. स्वमध्यो (ग) स्वमध्यै (क) स्वमध्यौ (ख) स्वमध्यो for (खमध्यै)
 (च) १. स्वमध्यो for (खमध्यै)
 २. कूर्क for (ऽर्क)
 १९. (ख) १. अर्कोदयास्तमययोर्विना for (अर्कोदयास्तमययोर्विना)
 २. राभि for (रात्रि)
 (च) १. अर्कोदयास्तमययोर्विना for (अर्कोदयास्तमययोर्विना)

सूर्यस्य मनुद्वितयं त्रिशो^४नं दिनदलेन तस्य प्राक् । $\frac{1}{8}\frac{3}{8}$
 तिथिघटिकाभिस्त्रयंशाधिकोनमूनाधिकं पश्चात् । $\frac{1}{8}\frac{3}{8}$ ॥ २० ॥
 द्युदले जिनलिप्तो^५नं दशनद्वितयं $(\frac{3}{8}\frac{3}{8})$ द्विशर ५२ कालो^६नु प्राक् ।
 पश्चाद्युतो^७नमिदोः सूर्यवहणं धन परिध्यंशाः ॥ २१ ॥

२०. (घ) १. $\frac{1}{8}\frac{3}{8} \parallel \frac{1}{8}\frac{3}{8}$ (ग) for $(\frac{1}{8}\frac{3}{8})$

२. तिथि + १५ + (ग) for (तिथि)

३. त्र्यंशा (ग) स्त्रियशाधिकोन १४।०॥१३।२०॥ for (स्त्रियंशाधिकोन)

(ग) ४. त्र्यंशोनं (क) for (त्रिशोनं)

५. पश्चात् व for (पश्चात्)

(च) २. + १५ + १ संख्या लुप्त

३. त्र्यं $\frac{1}{8}\frac{3}{8} \parallel \frac{1}{8}\frac{3}{8}$ शाधिको for (त्रयंशाधिको)

२१. (घ) १. कलोनं (ग) (क) (ख) कालोनं for (कालोनु)

२. यहां '५२' संख्या जो 'द्विशर' के बाद अंकित है, लिखी है ।

३. मंदोः for (मिंदोः)

(ग) ५. संख्या अंकित नहीं है ।

६. संख्यां अंकित नहीं है ।

(क) ७. सूर्यादृण for (सूर्यवहण)

(ख) ८. द्युदलेतिन for (द्युदलेजिन)

(च) ६. संख्यालुप्त १ कलोनं for (कालोनु)

२. + ५२ + ७ सूर्यवहण for (सूर्यवहण)

तद्युदलपरिध्यन्तर गृणाकृता त्रिज्यया स्वनतजीवा ।

ऊने धनमृणमधिके दिनार्द्ध परिधौ स्फुटः परिधिः ॥ २२ ॥

भुजफलचापं केन्द्रे षड्राश्यने खावृणं मध्ये ।

स्वभुजबलचापमिन्दौ षड्राश्यधिके धनं भवति ॥ २३ ॥

देशान्तराद्यमेवं स्पष्टीकरणं दिनार्द्धपरिधिभ्याम् ।

कृत्वा तत्तिथ्यन्त स्फुटपरिधिभ्यां स्फुटावसकृत् ॥ २४ ॥

२२. (घ) १. हुता (ग) (क) (च) for (कृता)

२. तृज्यया for (त्रिज्यया) (क) त्रिज्ययाश्च नतजीवा for (त्रिज्यया स्वनत-जीवा)

(ग) यहां निम्नांकित संख्या अधिक है—

३१	३१	५२	३०	३२	३०
३६	३६		४४	२८	४४
				८	

(क) ३. तत्

४. मधिका for (मधिके)

(ख) ३. तद्युदलं for (तद्युदल)

(च) ६. परिधौ for (परिधौ)

२३. (घ) १. षड्राश्यने (च) for (षड्राश्यने)

२. फल (च) for (बल)

(ग) ३. षड्राश्यधिके (क) षड्राश्यधिके (ख) षड्रास्याधिके for (षड्राश्यधिके)

२४. (क) १. तत्तिथ्यन्तः (ख) तत्तिथ्यन्तं for (तत्तिथ्यन्त)

प्राक् पश्चाद्वा याभिर्घटिकाभिर्दिनदलान्तः सूर्यः ।
 तिथ्यन्ते तद्रहिते त्रिशत् घटिकावशेषाभिः ॥ २५ ॥
 विपरीतमर्धरात्राच्चन्द्रग्रहणे शशी रविग्रहणे ।
 सूर्योयतस्ततस्ताभिरेव घटिकाभिरिदुरपि ॥ २६ ॥
 दिनदल परिधि स्फुट तिथिनतकेन्द्रज्यावधो गुणोर्कन्दोः ।
 इद्व धृति धृतिभि १६१ नवनववेदै ४६६ व्यासार्द्धकृतिर्भक्तः ॥ २७ ॥

१०६६२६००

२५. (घ) १. तद्रहित for (ग) (तद्रहिते) (ग) तद्रहितस्त्रिशद् for (तद्रहिते त्रिशत्) (क)
 तद्रहितं for (तद्रहिते)
 २. त्र्यंशद् (क) त्रिदशत for (त्रिशत्)
 (ग) ३. नतसूर्यः for (नतः सूर्यः)
 (ख) ४. घटिकाभि for (घटिकाभिः)
 ५. त्रिशदधिकावशेषाभिः for (त्रिशत्घटिकावशेषाभिः)
 (च) ३. दिनदलान्तत् सूर्यः for (दिनदलान्ततः सूर्यः)
 २. त्रिशद् for (त्रिशत्)
२६. (घ) १. यतस्वषः for (यतस्ततस्)
 २. चन्द्रग्रहणे (क) चन्द्रग्रहादिनिग्रहाणः for (चन्द्रग्रहणे)
 ३. रेवमय for (रेव)
 (च) २. चन्द्रग्रहणे for (चन्द्रग्रहणे)
२७. (घ) १. दज for (दल)
 २. व्या for (ज्या) (क) ज्यावाधो for (ज्यावधो)
 ३. कॅन्दोः (ग) (ख) कॅन्दो for (कॅन्दोः)
 ४. इद्वतिधृतिभि (ग) (क) इद्विधृतिभि for (इद्वधृतिधृतिभि)
 ५. भक्तः for (भंक्तः) (ग) (ख) कृतिभक्ति for (कृतिभंक्तः)
 ६. १०६६ ॥ २६०० for (१०६६२६००)
 (ग) ७. व्यासार्द्धकृति (क) व्यासार्द्धकृते for (व्यासार्द्धकृति)
 वि० रेखाङ्कित दोनों संख्याएं "वेदै" के पश्चात् एक स्थान पर हैं ।
 (१६१, ४६६)
 (क) ३. गुणोर्कस्तः for (गुणोर्कन्दोः)
 ८. नवनववेदै (च) for (नवनववेदै)
 वि० संख्याएं मूल में लुप्त हैं ।
 (च) ३. कॅन्दोः for (कॅन्दोः) ५. भक्तः for (भंक्तः)

फलविकला वा सूर्ये प्रागृणमसकृन्तते धनं पश्चात् ।
 केन्द्रफलमृणं चन्द्रेऽन्यथा धनं चेहृणं स्पष्टौ ॥ २८ ॥
 अर्कफलभुक्तिघाताद्भूगणकलाप्तं भुजांतरं रविवत् ।
 स्फुटभुक्तिरतीतैष्य ग्रहान्तरं वर्तमानेऽह्नि ॥ २९ ॥
 क्षयधनहानिधनानि प्राक् पश्चादन्यथा खेरिदोः ।
 प्राग्वत्पश्चात्स्वगतौ धनक्षयक्षयधनानि प्राक् ॥ ३० ॥
 ब्रह्मोक्तमध्यरविशशितदुच्चतत्परिधिभिः स्फुटीकरणम् ।
 कृत्वैनं स्पष्टतिथिर्द्वाभ्रष्टान्यतंत्रोक्तैः ॥ ३१ ॥

२८. (ग) १. धननं for (धनं)
 २. चेहृणं (क) मे ऋणं (ख) चेहृणं for (चेहृणं)
 (क) ३. चा प्रात्यपा for (चन्द्रेऽन्यथा)
 (ख) ४. विकल for (विकला)
 ५. सूर्यो for (सूर्ये)
 ६. मासकृते for (मसकृन्तते)
 ७. धृतिभिर्नवनववेदौ for (केन्द्रफलमृणं)
 (च) २. चेहृणं for (चेहृणं)
२९. (घ) १. भरणे for (भरण)
 २. +२१६०+(च)+२१६००+
 (क) ३. ह्निः for (ह्नि)
 (ख) ४. रतीतैष्यद् for (रतीतैष्य)
 ३. ज्ही for (ऽह्नि)
 (च) ५. अर्क for (अर्क)
 ४. रतीतैष्यद्ग्रहान्तरं for (रतीतैष्य ग्रहान्तरं)
 ३. ह्निः for (ऽह्नि)
३०. (क) १. 'धनानि' पद लुप्त है ।
 २. प्राग्वत् for (प्राक्)
 (ख) ३. +च+
३१. (घ) १. कृत्वैनं (ग) (क) (च) for (कृत्वैनं)
 २. स्पष्टतिथे for (स्पष्टतिथि)
 ३. च for (अ)
 (क) ४. स्फुटीकरणम् for (स्फुटीकरणम्)
 ५. कृत्रोक्तो for (तंत्रोक्तैः)

स्वदिनार्द्धं परिधिभुजकलचापं मध्यार्कचन्द्रयोः कृत्वा ।

पूर्ववदन्यत्स्पष्टं संव्यवहारार्थमेवं वा ॥ ३२ ॥

आर्यभट्टस्याज्ञानान्मध्यममन्दोच्चशीघ्रपरिधिना ।

न स्पष्टा भौमाद्याः स्पष्टा ब्रह्मोक्तमध्याद्यैः ॥ ३३ ॥

मंदोच्चनीचवृत्तस्य परिधिभागाः सितस्य विषमांते ।

नव ६ युग्मांते रुद्राः ११ शीघ्रौ जान्तेऽग्निरसयमलाः ॥ २६३ ॥ ३४ ॥

युग्मांतेष्टशरयमाः २५ मंदफलात्मध्यमः स्फुटो मध्यः ।

शीघ्रफलात्स्पष्टो सकृदेवं स्वफलैर्ज्ञगुरुसौराः ॥ ३५ ॥

३२. (घ) १. स्पष्टो (ग) स्पष्टौ (क) स्पष्टौ for (स्पष्टं)

(च) २. मध्यार्क for (मध्यार्क)

३३. (घ) १. परिधीनाम् (ग) (क) (च) for (परिधिना)

२. त for (न)

३. भौमाद्या for (भौमाद्याः)

(क) ४. स्पष्ट for (स्पष्टा)

(च) २. ते for (न)

३ भौमाद्या for (भौमाद्याः)

५. क्रमसंख्या लुप्त

३४. (घ) १. यमलाः (च) for (यमलाः)

२. ३४।२६३ for (२६३।३४) (क) संख्या लुप्त है ।

(क) ३. शीघ्रो (च) for (शीघ्रौ)

(ख) यह श्लोक यहां ३० वें श्लोक के पश्चात् है । यद्यपि इस प्रति में श्लोक संख्या नहीं दी गई है ।

(च) ४. विसर्गलुप्त

५. अग्रग्रहचिह्न लुप्त

३५. (घ) १. फलान् (ग) (क) (ख) मंदफला for (मंदफलात्)

(ग) २. मध्यम for (मध्यमः)

(क) ३. सौरः for (सौराः)

(ख) ४. युग्मांतिष्ठ for (युग्मांतिष्ठ)

५. शरयमा for (शरयमाः)

(च) १. फलान् for (फलात्)

बुधमंदपरिधिभागावसुरामाः ३८ सुरगुरोर्द्वयविक्षत् ।
 रविजस्यशून्यरामा ३० सशीघ्रपरिधिद्विगुणचन्द्राः ॥ ३६ ॥
 देवगुरोरष्टरसा ६८ भास्कर पुत्रस्य शरगुणाः ३५ स्पष्टाः ।
 कुजशीघ्रकेन्द्रपदगत ये अल्पज्याभिभागोनैः ॥ ३७ ॥

३६. (घ) १. बुधमंदपरिधि for (बुधमंदपरिधि)

२. +३३+(ग) (च)

३. ज (ग) (क) (ख) (च) for (स)

४. द्विगुण (ग) for (द्विगुण)

५. +१३२+(ग) (च)

(ग) ६. रामा for (रामाः)

(क) वि० मूल में अंकित संख्याएं यहां लुप्त हैं ।

(ख) ७. रंशा for (भागा)

८. त्रयस्त्रिंशत् for (त्रयस्त्रिंशत्)

९. चन्द्रा for (चन्द्राः)

(च) १०. रामाः for (रामा)

३७. (घ) १. रस्य (क) रस for (रसा)

२. शरगुणा स्पष्टाः । ३५ for (शरगुणाः ३५ स्पष्टाः)

३. अल्पज्या (ग) (क) for (अल्पज्या)

४. त्रि (ग) (क) (च) for (त्रि)

५. नौः for (नैः)

(च) २. शरगुणस्पष्टाः ३५ for (शरगुणाः ३५ स्पष्टाः)

३. अल्पज्या for (अल्पज्या)

सप्तभिरंशैर्गुणिता ६।४०^६ दिवर्द्ध^९ राशिज्यया हृताप्तांशैः ।

२३१

अधिकोनकुजमंदो^३ मृगकर्कादौ स्फुटौ^४ भवतीति ॥ ३८ ॥

तत्स्फुटपरिधिः^५ खनगाः ७०^९ शीघ्रस्फुटपरिधिराप्तभागोनाः ।

वेदजिनांश्चिशोनाः^६ २४३।३० स्फुटीकरणं^७ कुजस्यैवम् ॥ ३९ ॥

३८. (घ) १. गुणिता: (च) for (गुणिता)

२. २३१२ (ग) (च) for (२३१)

३. न: (ग) (क) (च) for (न)

४. स्फुटो (ग) (क) (ख) (च) for (स्फुटौ)

५. भवति (ग) (क) भवति (ख) भवति (च) for (भवतीति)

(ग) ६. यहाँ यह संख्या नहीं है (च) '४०' संख्या लुप्त

(क) ७. दिवर्द्ध for (दिवर्द्ध)

वि० मूल में दी गई संख्याएं लुप्त हैं ।

(ख) ८. हृताप्तांशः for (हृताप्तांशैः)

९. मृगकवचादौ for (मृगकर्कादौ)

(च) ९. मृगकर्कादौ for (मृगकर्कादौ)

३९. (घ) १. ७०४० (च) for (७०)

२. २४३।४० (ग) (च) for (२४३।३०)

३. स्फुटीकरणं (ग) स्पष्टीकरणं (ख) for (स्फुटीकरणं)

(ग) ४. रातभागोना for (रातभागोनाः)

५. स्त्रिशोनाः (ख) स्वांशोना for (स्त्रिशोनाः)

(क) ६. भागाः स्पष्टाः । (कुजशीघ्रस्फुट परिधिभागाभवति)

७. दूसरी पंक्ति—के ते वेदस्त्रंशोना एते ३४०^३ परं आप्तं भागोनाः ॥

वि० ऐसा प्रतीत होता है कि लिपिकार मूल श्लोक लिखना भूल गया ।

केवल टीका उपलब्ध है ।

(ख) ६. रातो ना for (रातभागोनाः)

(च) ८. तत्स्फुट for (तत्स्फुट) ९ परिधिः for (परिधि)

५. स्त्रिशोनाः for (स्त्रिशोनाः)

मन्दफलं मध्येऽद्धं तच्छीघ्रफलं च मध्यमे सकले ।
 मध्ये सकृत् क्षितिसुतः स्पष्टो भुक्तिः स्फुटाग्रहवत् ॥ ४० ॥
 ग्रहेन्द्रभुक्तिज्याकरगुणिताद्यजीवया भक्ता २१४ ।
 लब्धं स्फुटं परिधिगुणं भगणांशहतं कलाभिस्तु ॥ ४१ ॥

४०. (घ) १. फलं (ग) (क) (ख) फलस्य for (फल)

२. सकलो (ख) (च) for (सकले)

३. मध्येऽसकृत् (क) मध्यशकृत for (मध्येसकृत्)

४. भुक्तिः (ग) (च) for (भुक्ति)

५. क्षितिसुते (ख) for (क्षितिसुतः)

७. स्फुटौ for (स्फुटा)

(ख) ८. धा (च) द्वं for (ऽद्धं)

(च) ९. तत्शीघ्र for (तच्छीघ्र)

४१. (घ) १. ग्रहमंदकेन्द्र (ग) (क) ग्रहमंदकेन्द्रा (ख) ग्रहमंदकेन्द्र for (ग्रहेन्द्र)

२. ज्यतिर (ग) ज्यांतर (क) ज्यतिर (ख) ज्यांतर for (ज्याकर)

३. फलकबाभिः । (ग) (क) फलकलाभिः for (कलाभिस्तु)

(ग) ४. द्युजीवया (क) (ख) गुणिताद्या for (द्युजीवया)

(ख) ५. भक्ताः for (भक्ता)

६. स्फुटि for (स्फुट)

३. फलकलाभिः for (कलाभिस्तु)

(च) १. ग्रहमंदकेन्द्र for (ग्रहेन्द्र)

२. ज्यांतर for (ज्याकर)

३. फलकबाभिः for (कलाभिस्तु)

मृगकर्काद्याद्वनाधिका स्वमध्यमगतिः स्फुटार्कदोः ।

शीघ्रगतिमंदफलस्फुटभुत्तचूनां कुजादीनाम् ॥ ४२ ॥

शीघ्रफलं भोग्यजीवागुणिता माघजीवया विभजेत् ।

फलगुणितं व्यासार्द्धं विभाजयेत् शीघ्रकरणेन ॥ ४३ ॥

४२. (घ) १. मृगकर्काद्याद्वनाधिका (ग) (क) मृगकर्काद्याद्वनाधिका for (मृगकर्काद्याद्वनाधिका)

२. स्फुटार्कदोः (ग) (क) स्फुटार्कदोः for (स्फुटार्कदोः)

३. शीघ्रगतिं (क) शीघ्रगतिः for (शीघ्रगति)

४. भुत्तचूनां (ग) भुत्तचूनां (क) भुत्तचूनां (ख) for (भुत्तचूनां)

५. कुजादीनाम् । (ग) (क) (ख) कुजादीनाम् for (कुजादीनाम्)

(ग) ६. स्वमध्या for (स्वमध्यम)

७. मंदफल (ख) मदे for (मंदफल)

(ख) इस श्लोक का पूर्वार्धं लुप्त है—

८. शीघ्रगतिः for (शीघ्रगति)

९. 'फल' पद लुप्त है ।

(च) २. स्फुटार्कदोः for (स्फुटार्कदोः)

४. भुत्तचूनां for (भुत्तचूनां)

५. कुजादीनां for (कुजादीनां)

४३. (घ) १. शीघ्रफल (ग) (क) (ख) शीघ्रफल (च) for (शीघ्रफलं)

२. शृंगुणिता (ग) संगुणिता (क) संगुणिता (ख) for (गुणिता)

३. भजेत् for (विभजेत्)

(ग) ४. च्छीघ्र (च) for (त् शीघ्र)

५. विभजयेत् (ख) विभाजये (च) for (विभाजयेत्)

(ख) ६. व्यासार्धं for (व्यासार्द्धं)

७. शीघ्रकरणेना for (शीघ्रकरणेन)

(च) २. शृंगुणिता for (गुणिता) ८. माघ for (माघ)

लब्धोनाशीघ्रगतिस्फुटभुक्तिर्लब्धमधिकं चेत् ।

शीघ्रगतेः शीघ्रगतिः लब्धा संशोध्य वक्रगतिः ॥ ४४ ॥

देयमसुताय नेदं शपथैरपि दत्तमुकृतनाशाद्यैः ।

यात्राविवाहजातक फलस्फुटत्वं यतः स्पष्टैः ॥ ४५ ॥

मेषादितः प्रवृत्तानार्यभटस्य स्फुटाः युगस्यादौ ।

श्रीषेणस्य कुजाद्याः सूर्याद्यविष्णुचन्द्रस्य ॥ ४६ ॥

दूरभ्रष्टाः स्पष्टा श्रीषेणार्यभटविष्णुचन्द्रेषु ।

यस्मात् कुजादयस्तेषु न विदुषामादरस्तस्मात् ॥ ४७ ॥

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४४. (घ) १. शीघ्रगतिः (ग) (क) गति (ख) शीघ्रगतिः (च) for (शीघ्रगतिः)
 २. भवति लब्ध (ग) भवति लब्ध (ख) भवति लब्ध for (लब्ध)
 ३. शीघ्रगति (ग) (क) (ख) शीघ्रगतं for (शीघ्रगतिः)
 (क) ४. लब्धात् for (लब्धा)
 (ख) ५. संशोध्य for (संशोध्य)
 ६. वक्रगतिः for (वक्रगतिः)
 (च) २. + भवति +
 ३. शीघ्रगति for (शीघ्रगतिः)
४५. (घ) १. जातकं (ख) जातव for (जातक)
 २. स्पष्टै for (स्पष्टैः)
 (क) ३. नाशाद्यैः (ख) नशाद्यैः for (नाशाद्यैः)
 ४. यत्र for (यात्रा)
 (च) ५. नेदशपथै for (नेदं शपथै)
४६. (घ) १. स्फुटा (ग) (क) (ख) स्फुटा (च) for (स्फुटाः)
 २. ज्या (ग) द्या (ख) द्याः for (द्या)
 (ख) ३. विष्णुचन्द्रस्य for (विष्णुचन्द्रस्य)
 (च) २. सूर्याद्या for (सूर्याद्यैः)
४७. (घ) १. (चट) for (भट)
 (ग) २. स्पष्टाः (ख) for (स्पष्टा)
 (ख) ३. दूरभ्रष्टः for (दूरभ्रष्टाः)
 ४. 'आर्य' लुप्त है
 ५. चन्द्रेषु for (चन्द्रेषु)

अग्न्यष्टिभिरिषुमनुभिः शरसूर्यैरिषु रसेन्दुभिस्त्रिभवैः ।
 शीघ्रान्त्यकेन्द्रभागैर्भौमादीनां भवति वक्रम् ॥ ४८ ॥
 वक्रांशकैस्तद्वनैः ३६० रनुवक्रं तदधिकोन भागकलाः ।
 मंदफलस्फुट भुत्तचून शीघ्रभुत्तचाहुता दिवसाः ॥ ४९ ॥
 शीघ्रस्फुटाग्रहोना छेषे मध्यस्फुटांतराद्धं वा ।
 अधिकेधनमृणमूने स्फुटग्रहा मध्यमे कृत्वा ॥ ५० ॥

४८. (ग) १. अग्निष्टिभि (क) अग्न्यष्टिभि (च) for (अग्न्यष्टिभि)

२. रिषुमुनिभिः for (रिषुमनुभिः)

३. + भौ० व० कें० ॥ ५ । १३ । ० ॥ बु० व० कें० ॥ ४ । २५ । ० । ० ॥
 वृ० व० कें० ॥ ४ । ५ । ० । ० ॥ शु० व० कें० ॥ ५ । १५ । ० । ० ॥
 श० व० कें० ॥ ३ । २३ । ० । ० ॥ +

(ख) १. अग्न्याष्टिभि for (अग्न्यष्टिभि)

४. रसेन्दुभि for (रसेन्दुभि)

५. क्रम for (वक्रम्)

(च) २. रिषुमनुभि for (रिषुमनुभिः)

४९. (क) १. चक्रांशकै for (वक्रांशकै)

(ख) २. वक्त for (वक्रम्)

३. भुत्तचान for (भुत्तचून)

५०. (घ) १. स्फुट (ग) (क) for (स्फुटा)

२. ग्रहान् (ग) (क) ग्रहान् for (ग्रहा)

(क) ३. शीघ्रात् (ख) for (शीघ्र)

४. ग्रहोनात् for (ग्रहोना)

(ख) ५. छेषे for (छेषे)

६. स्फुटार्धं वा for (स्फुटांतराद्धं वा)

७. नष्टमृणमूने for (नष्टमृणमूने)

(च) २. स्फुटग्रहान् for (स्फुटग्रहा)

८. यहां क्रम संख्या मूल से “१५०” अंकित है ।

वि० यहां पर जो सारणी दी गई है । वह मूल पाठ में ५२ वें श्लोक में दी गई है ।

राशिषु चतुर्षु वक्रं षट्स्वति वक्रमनुवक्रमष्टासु । ४ । ५ । ८

अप्राप्ता प्रीतीतकाला भुत्तया सैवोद्धृता दिवसाः ॥ ५१ ॥

अष्टयमैः कृतचन्द्रैर्मुनीन्दुभिर्भौमजीव रविजानाम् ।

उदयप्रागस्तमयस्तदूनवक्रांशक पंचात् ॥ ५२ ॥

५	४	४	४	३
१३	२५	५	१५	२३
०	०	०	०	०
०	०	०	०	०

५१. (घ) १. वक्रं for (वक्रं)

२. ४ । ५ । ८ (ग) (च) for (४ । ५ । ८)

३. अप्राप्तातीतकला (ग) अप्राप्तातात्कला (ख) अप्राप्तातीतकाला for (अप्राप्ताप्रीतीतकाला)

४. सैवोद्धृता (ग) (क) (ख) for (सैवोद्धृता)

(ग) ५. दिवसा (ख) (च) for (दिवसाः)

(क) ३. अप्राप्तातीतकला for (अप्राप्ताप्रीतीतकाला)

(ख) ६. षट्स्वति for (षट्स्वति)

७. 'नु' पद लुप्त है ।

८. भुत्तया for (भुत्तया)

(च) ६. 'षट्स्व' लुप्त ० अप्राप्तातीतकला for (अप्राप्ताप्रीतीतकाला)

५२. (घ) १. वक्रांशकैः (ग) (क) चक्रांशकैः (ख) वक्तांशकैः for (वक्रांशकैः)

२. पञ्चात् (ग) (क) (ख) पञ्चात् for (पञ्चात्)

३. यहां यह तालिका ५०वें श्लोक के साथ है (ख) लुप्त है

(ग) ४. अष्टयमैः (ख) अष्टयमै for (अष्टयमैः)

५. भौमजा (क) भौम for (भौम)

६. +२८ । १४ । १७ +

७. उदयः (ख) for (उदय)

३. यहां यह तालिका नहीं दी हुई है (क)

(क) ८. रविजानाम् for (रविजानाम्)

(ख) ९. कृतचन्द्रैः for (कृतचन्द्रैः)

१०. मुनिदुभौम for (मुनीन्दुभिर्भौम)

११. तादन for (तदन)

(च) १. वक्रांशकैः for (वक्रांशकैः) २ पञ्चात् for (पञ्चात्)

खशरै^८जिनै^५ज्ञसितयोः २८ । १४ । १७ । ५० । २४ रिषु^८तिथिभिर्मुनिनगै-
 दुभिः पश्चात् । १५५, ११७७
 उदयास्तमयो^६ व्यस्तौ^२ मंडलभागैस्तद्वनैः^३ प्राक् ॥ ५३ ॥
 स्पष्टा^८द्युराभिदलयोरव्युदयान्तमये^२ यौ रविचरा^६द्धात् ।
 एष्यत्यधिके^८ तीतादवक्रिते^३ हीनौ^५ ॥ ५४ ॥

५३. (घ) १ १५५११७७ (ग) १५५ । १७७ for (१५५, ११७७)

२. व्यस्तौ for (व्यस्तौ)

३. मंडलभागैः for (मंडलभागै)

४. प्राक् for (प्राक्)

(ग) ५. ज्ञसितयोः । ५० । २४ ॥ (ख) ज्ञासितयो (च) for (ज्ञसितयोः)

६. उदयास्तमयौ (क) (ख)

७. +३६०+

(क) वि० संख्याएँ मूल में नहीं दी गई हैं ।

(ख) ८. स्वशरै जिनै for (खशरैजिनै)

५४. (घ) १. त्रि for (भि) (ग) (क) (ख) रात्रि for (राभि)

२. रव्युदयोस्तमययो (ग) रव्युदयास्तमययो (ख) for (रव्युदयान्तमये यौ)

३. कृतो (ग) (क) (च) for (क्रिते)

४. हीने (ग) (क) for (हीनौ)

(क) २. रव्युदयास्तमययो for (रव्युदयान्तमये यौ)

५. +वक्रितो+

(ख) ६. रविचराधात् for (रविचराद्धात्)

७. एष्यात्यधिके for (एष्यत्यधिके)

८. तीतादेवक्रितो for (तीतादवक्रिते)

(च) २. रव्युदयास्तमये for (रव्युदयान्तमये)

जिनभा॒गज्या॑ गु॒णिता॑ सू॒र्याद्या॑ व्यास॒दल॑हृताल॒ब्धम् । ३२७०
 इष्टा॑पक्रमजीवा विषुवदु॒ग् दक्षि॑णा सवितुः ॥ ५५ ॥
 इष्टा॑पक्रमवर्गमिज्यावर्गाद्विशो॒ध्य १०६६१६०० शेष॑पदम् ।
 विषुवदु॒ग् दक्षि॑णतः स्वाहोरात्र्याद्धं विष्कं॒भः ॥ ५६ ॥

५५. (घ) १. + १३२६ + (च)

२. + ३२७० + (ग) (च)

३. यह संख्या यहाँ पर 'हृता' के पश्चात् है ।

४. दृष्टा for (इष्टा)

५. विषुवदुद्दक्षिणा (ग) विषुवदुद्दक्षिणे for (विषुवदुद्दक्षिणा)

६. सवितु (ख) सवितु (च) for (सवितुः)

(ग) ७. + १३२६ + सूर्यज्या (क) सूर्यज्या (ख) सूर्यज्य for (सूर्याद्या)

(क) ८. दक्षिणे (ख) दक्षिण for (दक्षिणा)

(ख) ९. जिनभागाज्या for (जिनभागज्या)

(च) ५. विषुवदुद्दक्षिणा for (विषुवदुद्दक्षिणा)

५६. (घ) १. वर्ग त्रिज्या (ग) (क) (ख) वर्गत्रिज्या for (वर्गमिज्या)

२. वर्गाद्विशोध्य (ख) वर्गाद्विशेषपदम् for (वर्गाद्विशोध्य)

३. दक्षिणतः (च) for (दक्षिणतः)

४. स्वाहोराद्धं (ग) स्वाहोरात्र्याद्धं (क) स्वाहोरात्र्याद्धं for (स्वाहोरात्र्याद्धं)

(ग) ५. + १०६६२६०० +

(ख) ६. इष्टमपक्रम for (इष्टापक्रम)

७. 'ग्' लुप्त

४. स्वाहोरात्र्यार्ध for (स्वाहोरात्र्याद्धं)

८. विष्कभ्रः for (विष्कंभः)

(च) १. वर्ग त्रिज्या for (वर्गमिज्या)

४. स्वाहोराद्धं for (स्वाहोरात्र्यार्ध)

क्रान्तिज्या विषुवच्छायया गुणा द्वादशो धृता क्षितिजा ।

स्वाहोरात्रेऽनष्टा व्यासार्धेनाहता भक्ता ॥ ५७ ॥

स्वाहोरात्राद्धेन क्षयवृद्धिज्याधनुश्चरप्राणाः ।

षट्कोद्धृता विनाड्यो विनाडिका नाडिका षष्ट्या ॥ ५८ ॥

चरदलघटिका गुणिता भुक्तिः षष्ट्याहता कलाद्याप्तम् ।

ऋणमुदयेऽस्तमये धनमुत्तरगोलेऽन्यथा याम्ये ॥ ५९ ॥

५७. (घ) १. त्सायाया (ग) द्वायया (ख) विषुवच्छायाया for (विषुवच्छायया)
 २. दृता (ग) (ख) हता for (धृता)
 ३. स्वाहोरात्रेऽनष्टा (ख) (क) स्वाहोरात्रेऽनष्टा for (स्वाहोरात्रेऽनष्टा)
 ४. भक्ताः (ग) for (भक्ता)
 (ग) ५. व्यासार्धेनाहता (ख) सार्धेन हता for (व्यासार्धेनाहता)
 (ख) ६. गुण for (गुणा)
 (च) २. दृता for (धृता) ३. स्वाहोरात्र for (स्वाहोरात्रे)
 ५. व्यासार्धे for (व्यासार्धे) ४. भक्ताः for (भक्ता)

५८. (घ) १. दृता (ग) (क) (ख) (च) for (धृता)
 २. षष्ट्याः (ख) षष्टा for (षष्ट्या)
 (ग) ३. विड्यो for (विनाड्यो)
 (ख) ४. शर for (चर)
 ५. + भवति नाड्यो +
 ६. 'डका' लुप्त है
 (च) २. षष्ट्याः for (षष्ट्या)

५९. (घ) १. घाप्तम् (ग) घातम् (ख) द्यप्तम् for (द्याप्तम्)
 २. गोलेऽन्यथा (ग) (च) for (गोलेऽन्यथा)
 (ग) ३. पल for (दल)
 ४. ऋण for (ऋण)
 ५. अस्तमये for (अस्तमये)
 (क) ६. भुक्ति for (भुक्तिः)
 ७. हता (च) for (हता)
 ८. उत्तरं for (उत्तर) (ख) धनुत्तरगोलेऽन्यथा for (धनुत्तरगोलेऽन्यथा)
 (च) ५. अवग्रहलिङ् लुप्त

दिनरात्रिमानघटिकाश्चराद्धनाडीभिर्हृत्तरगोले ।

पंचदश^२ १५ युक्तहीना^४ याम्ये^५ हीनाधिका^६ द्विगुणाः^३ ॥ ६० ॥

भान्यश्विन्यादीनि^५ ग्रहलिप्ता^६ खखवसु^१ ८०० दृताल्लब्धम् ।

भुक्तिहृते^५ गतगम्ये^३ दिवसाः^३ दिवसा^३ षष्ट्याहते^५ घटिका ॥ ६१ ॥

अर्को^५ न चन्द्र^१ लिप्ताः^१ खयम^६ स्वर^७ ७२० भाजिता^१ फलं^५ तिथयः ।

गतगम्ये^५ षष्टिगुणे^१ भुत्तचन्तर^१ भाजिते^६ घटिका ॥ ६२ ॥

६०. (ग) १. हृत्तरे (क) (ख) कत्तरे for (हृत्तर)

२. यह संख्या लुप्त है

३. यहां (:) लुप्त हैं (क)

(क) ४. युक्ति for (युक्त)

५. ६ 'याम्ये हीना' पद लुप्त हैं । (ख)

(च) १. हृत्तरे for (हृत्तर)

६१. (घ) १. खखवसूद्धता (क) (ख) खखावस्तूद्धता for (खखवसु ८०० दृता)

२. यह '८००' संख्या यहां न होकर 'लब्धम्' के पश्चात् है (ग)

३. 'दिवसा' इस प्रति में विद्यमान नहीं (क) (ख) विवसाः for (दिवसा)

(ग) ४. यह पद यहां लुप्त है (ख)

(क) ५. भान्यश्विन्यादीनि (ख) भन्याश्विन्यादीनि for (भान्यश्विन्यादीनि)

६. लिप्ताः for (लिप्ता)

(ख) ७. भुक्तिहृते for (भुक्तिहृते)

८. गुणे च घटिका for (षष्ट्याहते घटिका)

(च) १. वसूद्धता for (वसुद्धता)

६२. (घ) १. लिप्ता (क) for (लिप्ताः)

२. गुण (ग) for (गुणे)

३. घटिकाः (च) for (घटिका)

(ग) ४. यह संख्या 'भाजिता' और 'फल' के बीच में है

५. तिथयः (ख) तिथ्ययः for (तिथयः)

(क) ६. खयमा for (खयम)

(ख) ७. स्वर for (स्वर)

(च) ८. अर्को for (अर्को) ४. संख्या लुप्त

रविचन्द्रयोगलिप्ताः खयमस्वरभाजिताः फलं योगः ॥
 गतगम्ये षष्टिगुणे भुक्तिसमासाद्धृते नाड्यः ॥ ६३ ॥
 राश्यंशकला विकलाः स्फुटमासांते लिप्तिका विकला ।
 पक्षांते तिथ्यंते समा रवीन्दोः कला विकलाः ॥ ६४ ॥

६३. (घ) वि० यह श्लोक इस प्रति में उपलब्ध नहीं । न इस संख्या का कोई दूसरा श्लोक ही । ऐसा प्रतीत होता है कि लिपिकार द्वारा यह श्लोक लिखने से रह गया ।

(ग) यह श्लोक इस प्रति में भी उपलब्ध नहीं है ।

(क) इस प्रति में उपलब्ध नहीं ।

(च) १. योगाः for (योगः) २. समासाद्धृते for (समासाद्धृते)

वि० यह श्लोक इस प्रति में १५A पृष्ठ पर ऊपर की ओर किसी अन्य हाथ से लिखित है ।

६४. (घ) १. विकलाः (ग) (क) (च) (विकला)

२. रवीन्दोः (ग) (क) रवीस्ताः (ख) रवीन्दोः (च) for (रवीन्दोः)

(ग) ३. मासांते (घ) (क) (ख) मासांते for (मासांते)

वि० इसकी श्लोक संख्या ६३ है ।

(क) ४. राश्यंश (ख) राशांश for (राश्यंश)

५. विकला for (विकलाः)

६. लिप्तिको for (लिप्तिका)

७. विवरलाश्चा for (विकलाः)

इसकी श्लोक संख्या ६३ है ।

(ख) ८. पक्षातो for (पक्षांते)

(च) ३. मासांते for (मासांते)

कृ०णचतुर्दश्यन्ते^१ शकुनिं^२ पर्वणि^३ चतुष्पदप्रथमे ।
 तिथ्यद्धते^४ नागं^५ किस्तुघ्नं^६ प्रतिपदाद्यद्ध^७ ॥ ६५ ॥
 व्यकटु^८ कला भक्ताः^९ खरसगुराः^{१०} ३६० लब्धमूनमेकेन ।
 चलकरणानि^{११} ववादीन्यग^{१२} हृतशेषे तिथिवदन्यत् ॥ ६६ ॥

६५. (घ) यह श्लोक इस प्रति में उपलब्ध नहीं है ।

- (ग) १. ईश्यन्ते शशकुनिः for (दंश्यन्ते शकुनि) (ख) चतुर्दशांते for (चतुर्दश्यन्ते)
 २. चतुष्पदं (क) (ख) (च) for (चतुष्पद)
 ३. तिथ्यद्धतेनागं (क) तिथ्यद्धेत्ये (ख) तिथ्यवेत्यनागः for (तिथ्यद्धते नागं)

- (क) ४. शकुनिः (ख) for (शकुनि)
 ५. मार्गं for (नागं)

वि० इसकी श्लोक संख्या ६४ है ।

- (ख) ७. किस्तुघ्नप्रति for (किस्तुघ्नं प्रति)
 (च) ३. तिथ्यद्धते for (तिथ्यद्धते)

६६. (घ) १. वदन्यतः for (वदन्यत्)
 इस श्लोक की क्रमसंख्या ६५ है । (ग) (क)

- (ग) २. +७+(च)
 (क) ३. भक्ता for (भक्ताः)
 ४. त्वर (स्व) स्वरस for (खरस)
 ५. लब्ध (च) for (लब्ध)
 ६. तिथिन्यत् ॥ ६६ ॥ (ख) तिथि वदन्यात् for (तिथिवदन्यत्)
 (ख) ७. व्यकट्रकला for (व्यकटुकला)
 ८. वल for (चल)
 ९. च for (व)

(च) १०. क्रमसंख्या ॥ ६५ for (६६)

इह नोक्तानि बहुत्वात् स्पष्टगतेरुत्तरेभिधास्यामि ।
 संक्रांतिभित्थिकरण व्यतिपाताद्यंत गणितानि ॥ ६७ ॥
 ज्या परिधि स्पष्टीकरण दिनगतिचराद्धं करणेषु ।
 स्फुटगतिरध्याय सप्तषष्टिरार्या द्वितीयोऽयम् ॥ ६८ ॥
 इति ब्रह्मगुप्ते २योऽध्यायः ॥

६७. (घ) १. थिमकरण for (भित्थिकरण)
 वि० इसकी श्लोक संख्या ६६ है । (ग) (क)

(क) २. बहुत्वत् for (बहुत्वात्)
 ३. स्पष्टगते for (स्पष्टगते)
 ४. ऽभिधास्यामि for (भिधास्यामि)
 ६. 'करण' पद लुप्त है ।
 ७. व्यतिपाताद्यंत for (व्यतिपाताद्यंत)

(च) ४. वधास्यामि for (भिधास्यामि)
 ८. ॥ ६६ ॥ for (॥ ६७ ॥)

६८. (घ) १. + भित्थि + (ग) (ख)
 २. गति रध्यायः (ग) (क) (ख) गत्यध्यायः for (गतिरध्याय)
 ३. द्वितीयोऽयम् (ग) (च) for (द्वितीयोऽयम्)
 इसकी श्लोक संख्या ६७ है । (च)
 ४. 'इति'—से 'अध्यायः' तक यहां अंकित नहीं इस अधिकार में केवल ६७ श्लोक हैं । (क)

(ग) ५. या for (ज्या)
 ६. करणं (ख) करणा for (करण)
 ७. दिनमानचराद्धं (ख) दिनरात्रिचराद्धं for (दिनगतिचराद्धं)
 ४. 'इति श्रीब्रह्मसिद्धान्ते स्फुटिकर्णाधिकारो द्वितीयः' यह नोट और ही लेखनी का है, कागज के ऊपर दिया गया है ।

(क) ८. परिधिः for (परिधि)

(च) १. + भित्थि २. रध्यायः for (रध्याय)
 ४. 'इति' से 'अध्यायः' तक अंकित नहीं है ।

पूर्वापरयोर्विद्धो^१ तुल्य छायाग्रयो दिगपराद्याः ।

पूर्वान्यः क्रान्तिवशात्तन्मध्यात् शंकुतलमितरे ॥ १ ॥

नृद्धायाग्रजमत्स्य द्वयमध्यगसूत्रयोर्द्युतिर्यत्र ।

सोत्तरगोले याम्या शंकुतला दक्षिणे सौम्या ॥ २ ॥

छायाग्रभ्रमरेखा सूत्रद्युतेर्वृत्तपरिधिरप्रस्पृक् ।

मध्यछायान्तरमुदगीतरं वा शंकुमण्डलयोः ॥ ३ ॥

१. (घ) १. विद्ध (ग) विद् (क) विन्दु (ख) विन्दु for (विद्धो)

२. दिगपराद्यः (ग) दिगपरार्धः (क) दिगपराधः for (दिगपराद्याः)

(ग) ३. शंकुतलमितरे (क) (ख) for शंकुतलमितरे)

(क) ४. तन्मध्या (ख) तन्मध्य for (तन्मध्यात्)

(ख) २. दिगपराद्यः for (दिगपराद्याः)

५. मूर्धन्याः for (पूर्वान्यः)

(च) २. दिग for (दिग)

२. (घ) १. नृद्धायाग्रजमत्स्य (क) त्रिद्धायाग्रजमत्स्य (ख) त्रिद्धायाग्रजमत्स्य for (नृद्धायाग्रजमत्स्य)

(ग) १. त्रिद्धायाग्रजमद्य for (नृद्धायाग्रजमत्स्य)

२. युति for (द्युति)

३. शंकुतला (क) कुतला for (शंकुतला)

(क) ४. यत्र for (यत्र)

५. याम्यान् for (याम्या)

(क्षेप) क्षेपक तत्काले द्विवरं क्रान्त्यो लंबेन भाजितं गुणयेत् ।

तत्करणेन छायायाः प्राचीलब्धां गुरौरयनैः ॥ २ ॥

इतिक्षेपः

(ग) यह श्लोक इसी 'प्रति' में वह भी 'क्षेप' के नाम से उपलब्ध है ।

(क) यह श्लोक इस प्रति में नहीं है ।

(च) यह श्लोक इस प्रति में नहीं है ।

३. (घ) १. युते (ग) (क) युते (ख) (च) for (द्युते)

२. वृत्तस्पृक् (ग) वृत्त (ख) वृत्त (च) for (वृत्त)

३. सुदगितरं (ग) मुदगिरद्वा (क) मुदगितरथा for (मुदगीतरं)

४. मंडलयो (च) for (मंडलयोः)

(क) ५. 'वा' पद लुप्त है । (ख) द्वा

(ख) ६. 'प्र' लुप्त है

७. मध्या for (मध्य)

३. मुदगितर for (मुदगीतरं)

छायावृत्तेऽर्कागा कर्णगुणा व्यासदल हृत्कर्काग्रा ।
 विषुवच्छाया याम्या तदन्तरैक्यं भुजस्याग्रे ॥ ४ ॥
 शंकुप्राच्यपरा या छाया भुजकृतिविशेषमूलं नयत् ।
 तत्प्राच्यपरछाया भुजाग्रयोरन्तरं कोटिः ॥ ५ ॥
 दिग्मध्ये छायाग्रं कृत्वा शंकोर्यथादिशं भ्रमणम् ।
 दिग्मध्यस्थितशकोः छायाग्रं भ्रमति विपरीतम् ॥ ६ ॥

४. (घ) १. वृत्तेर्काग्रा (ग) (ख) वृत्तेर्काग्र for (वृत्तेऽर्काग्रा)
 २. विषुवच्छायायाम्या (ग) विषुवच्छायायाम्या for (विषुवच्छाया याम्या)
 ३. भुजोस्याग्रे (ग) भुजोस्याग्रे (क) भुजोस्याग्रे for (भुजस्याग्रे)
 (ग) ५. कर्णगुणा for (कर्णगुणा)
 (क) २. विषुवच्छाया for (विषुवच्छाया)
 (ख) ४. हृत्कर्काग्रा for (हृत्कर्काग्रा)
 ३. भुजोस्याग्रे for (भुजस्याग्रे)
 (च) १. वृत्तेर्काग्रा for (वृत्तेऽर्काग्रा) ४. हृत्कर्काग्रा for (हृत्कर्काग्रा)
 २. विषुवच्छाया for (विषुवच्छाया) ३. भुजोस्याग्रे for (भुजस्याग्रे)
५. (घ) १. परयो (ग) परायाः (क) परायाः for (पराया)
 २. 'न' इस प्रति में नहीं है । (ग) (क) (च)
 ४. भुजग्रयो for (भुजाग्रयो)
 (ग) ५. शंकुः (ख) शकुः for (शंकु)
 (क) ६. कौशि for (कोटिः)
 (ख) ७. प्राच्या for (प्राच्य)
 ८. रन्तरे for (रन्तरं)
 (च) ६. तत्प्राच्यां for (तत्प्राच्य) ४. भुजग्रयो for (भुजाग्रयो)
६. (घ) १. भ्रवति (क) for (भ्रमति)
 (क) २. दिग्मध्ये (ख) दिग्मध्ये for (दिग्मध्ये)
 ३. शंकोश् (ख) शंको for (शंकोः)
 (ख) ४. शंकोर्यथादिशं for (शंकोर्यथादिशं)
 ५. दिग्मध्ये for (दिग्मध्य)
 (च) ३. शकोः for (शंकोः)
 ६. विपरितं for (विपरीतं)

शंकुल^५बछाया^१क्षज्या^१ तद्वर्गसंयुते^२ मूलम् ।

विषुवत्कर्णछाया^३ कर्णोत्पदा^४ शंकुः ॥ ७ ॥

उन्नतजीवाकोटिः^५ छाया^६ द्विज्या^३ भुजो^४ नतज्या^५ वा ।

कर्णछायावृत्तं^७ व्यासार्द्धं^८ द्वयमतोन्यत्र ॥ ८ ॥

७. (घ) १. क्षज्या (ग) क्षज्य (ख) वज्या for (क्षज्या)

२. मूलम् (च) for (मूलम्)

३. विषुव तिथिविषुव (ग) विषुवति विषुवति for (विषुवत्)

४. कर्णोत्पदा (ग) (क) कर्णोत्पदा for (कर्णोत्पदा)

(ग) ५. शंकुलम्बः (क) शंकुलम्ब (ख) शंकुलम्ब for (शंकुलम्ब)

६. कर्णः छाया (क) कर्णछाया for (कर्णछाया)

(क) ७. +विषुवति+ (च)

(ख) ७. +विषुवति+

४. कर्णोत्पदा for (कर्णोत्पदा)

(च) १. क्षज्या for (क्षज्या) ४. कर्णोत्पदा for (कर्णोत्पदा)

८. (घ) १. कोटिछाया for (कोटिः छाया) (ख) उन्नतजीवकोटि for (उन्नतजीवा-कोटिः)

२. यत्रः for (यत्र)

(ग) ३. द्विज्या (क) शज्या for (द्विज्या)

४. भुजानतज्यावा for (भुजोनतज्यावा) (ख) भुज्या for (भुजो)

५. कर्णः for (कर्ण)

(क) ६. वा (छ) यः for (छाया)

७. तस्या (ज्या) या for (तज्या वा)

८. वृत्तव्यवसार्द्धं for (वृत्तं व्यासार्द्धं)

९. द्वयासनोत्पदा for (द्वयमतोन्यत्र)

इसकी श्लोक संख्या ६ है, संभवतः यह मूल है ।

(ख) १०. सार्द्धं for (सार्धं)

(च) १. कोटि for (कोटिः) ३. द्विज्या for (द्विज्या)

शं^३कु छाया^३ कृत्योस्त्रिज्या^६ कृतितत्समास^४ गुणहृतया^१ ।

मूलं^२ लम्बाक्षज्येस्तदंशकास्तद्वनुर्भागाः^५ ॥ ९ ॥

विषुवत्कर्णहते^६ वा शं^३कु छायागते^३ पृथक् ।

त्रिज्ये^५ त्रिज्येतर जीवा^१ लंबाक्षांसो^२ क्रमज्योना ॥ १० ॥

६. (घ) १. हृतयो (ग) हृतयोः (ख) हृतयोः for (हृतया)

२. मूले (क) (ख) for (मूलं)

३. लंबाक्षज्येस्तदंश (क) लंबाक्षस्थे for (लंबाक्षज्येस्तदंशं)

४. तद्वनुर्भागाः (क) सद्बक्रभागाः (ख) तद्वनुभागः for (तद्वनुर्भागाः)

(क) ५. नृत्यमासनस्य सूत्रयोः for (तत्समासगुणहृतया)

६. तदसंकाश (ख) तदशकास्व for (तदंशका)

इसकी श्लोक संख्या ८ है

(ख) ७. क्वाया for (छाया)

(च) ३. लम्बाक्षजे for (लम्बाक्षजे) ६. तदंशका for (स्तदंशका)

१०. (घ) १. जीवा वालंबाक्षांशो (क) (ख) जीवावलंबाक्षांशो for (जीवालंबाक्षांशो)

२. त्क्रमज्योना (क) कामावना (ख) क्रमज्योना for (क्रमज्योना)

३. छायाहते (ग) (क) छायाहते (ख) हते for (छायागते)

(ग) ४. लंबाक्षांशो for (लंबाक्षांसो)

(क) ५. त्रिज्येतर (ख) त्रिज्ये for (त्रिज्येतर) इसकी श्लोक संख्या ११ दी है ।

परन्तु यह भूल प्रतीत होती है क्योंकि इसकी टीका के अन्त में १० लिखा है ।

(ख) ६. विषुवत्कर्णहते for (विषुवत्कर्णहते)

(च) ३. छायादगते for (छायागते)

२. लंबाक्षांशोत्क्रमज्योना ।

नवते १० लम्बांशात्प्रोज्य ज्यावेतराक्षलम्बज्ये ।

शंकुछायागुणिते छाया द्वादशहृते वान्ये ॥ ११ ॥

लंबाक्षज्यावर्गं प्रोह्यज्या कृतेः पदं वान्याः ।

अन्यत्र सर्वदोन्नत जीवांशा नयनमेव ॥ १२ ॥

इष्टदिनाद्धनतांश क्रान्त्यंशैक्यांतरं क्रियतुलादौ ।

अक्षांशा याम्यायां छायायामंतरमजादौ ॥ १३ ॥

११. (घ) १. लंबाक्षांशात्प्राप्सज्या (ग) लंबाक्षांशान् (क) लंबाक्षांशान् (त्) for (लंबांशात् प्रोज्यज्या)

(ग) २. यह संख्या लुप्त है (क)

३. प्रोह्य ज्यवेतराक्ष (क) प्रोह्यज्या (ख) प्राज्याज्याधं for (प्रोज्यज्यावे-तराक्ष)

(क) ४. नवतै for (नवते)

(ख) १. लंबाक्षांशान् for (लम्बांशात्)

५. लंबज्यो for (लंबज्ये)

(च) १. लंबाक्षांशात् for (लम्बांशात्)

१२. (घ) १. प्रोक्तज्याकृतेः (ग) प्राज्यत्रिज्योक्तः (क) प्रोह्य त्रिज्या for (प्रोह्यज्याकृतेः)

२. वान्या (ग) (क) वान्यः for (वान्याः)

३. नतजीवांशा (ग) (क) (ख) नजीवांशा for (नतजीवांशा)

४. मेवम् (ग) (च) for (मेव)

(ग) ५. वर्ग (ख) वर्ग for (वर्ग)

(ख) १. प्रोज्या त्रिज्या for (प्रोह्यज्या)

४. नयनमवम् for (नयनमेव)

(च) १. प्रोज्य for (प्रोह्य)

२. वान्या for (वान्याः)

१३. (घ) १. दिनाद्धनतांश (ख) दिनाद्धनतांश for (दिनाद्धनतांश)

(ग) २. क्रान्ति (क) क्रान्त्यां (ख) क्रान्त्यै for (क्रान्त्यं)

(ख) ३. शैक्यांतर for (शैक्यांतरं)

४. तुल्यादौ for (तुलादौ)

५. अक्षांश for (अक्षांशा)

६. याम्यायां for (याम्यायां)

७. 'या' लुप्त है

(च) १. दिनाद्धनतांश for (दिनाद्धनतांश)

मेषवृषमिथुनजा^१ स्वाहोरात्र्याद्ध^२ चरदलप्राणान्^३ ।
 प्राग्वत्कृत्वा स्वाधो विशोध्य चरखंडकप्राणाः ॥ १४ ॥
 मिथुनाहोरात्र्याद्ध^१ क्रियाहोरात्रदलहत^२ गुणितम्^३ ।
 तज्ज्याभिराप्तं चापान्तराणि लंकोदयप्राणाः ॥ १५ ॥
 ज्यावर्गात्तत्क्रान्तिज्या वर्गोनात्तत्पदाहता त्रिज्या ।
 स्वाहोरात्र्याद्ध^१ हताश्चापांतराण्यथवा ॥ १६ ॥

१४. (घ) १. जीवा (ग) (क) (ख) जीवा (च) for (जा)
 २. रात्राद्धं (ग) (क) रात्रधं (ख) रात्रार्धं for (रात्र्याद्धं)
 (ख) ३. चरदप्राण (वा) न् । for (चरदलप्राणान्)
 ४. स्वाधो for (स्वाधो)
 ५. च खंडक प्राणाः for (चरखंडकप्राणाः)
 (च) २. रात्राद्धं for (रात्र्याद्धं)
 ५. चरखंडक प्राणाः for (चरखंडकप्राणाः)
१५. (घ) १. रात्राद्धं क्रियाद्यहो for (रात्राद्धंक्रियाहो) (ख) रात्रार्धं for (रात्राद्धं)
 २. रात (क) (ख) रात for (राप्तं)
 (ग) ३. क्रियाद्य (क) क्रियाद्यहो (ख) क्रियाद्यहो for (क्रियाहो)
 (क) ४. हतं (च) for (हतं)
 (ख) ५. रात्रदलं for (रात्रदल)
 ६. तज्ज्याभि for (तज्ज्याभि)
 ७. चापान्तराणि for (चापान्तराणि)
 ८. प्राणः for (प्राणाः)
 (च) ३. क्रियाद्यहोरात्र for (क्रियाहोरात्र)
 ६. तद्याभिरात for (तज्ज्याभिराप्तं)
१६. (घ) १. वर्गोनात्पदाहता (ग) वर्गो ना तत्पदाहता for (वर्गोनात्तत्पदाहता)
 २. त्रिज्या for (त्रिज्या)
 ३. हताः (ख) हतास्वार्धाश् for (हता)
 ४. ण्यथावाः for (ण्यथवा) (ख) चापांतराण्यथवा for (चापांतराण्यथवा)
 (क) मूल श्लोक यहां उपलब्ध नहीं है । केवल टीका अंकित है ।
 (ख) १. नात्यादा for (नात्तत्पदा)
 (च) ५. ज्यावर्गात्तत्क्रान्तिज्या for (ज्यावर्गात्तत्क्रान्तिज्या)
 १. वर्गोनात्पदाहता
 ३. हताश्चापश् for (हताश्)

स्वचरासुभिः^१सूनयुता^२ १६१७ क्रमोत्^३क्रमस्थैः^४ क्रमोक्रमन्यस्ताः^५ ।

उदयप्राणा व्यस्ताश्चार्कं तात्कालिकं कृत्वा ॥ १७ ॥

रविणा भुक्त्याराशेः^३ कला गुणाः^४ स्वोदयासुभिर्भक्ताः^५ ।

राशिकलाभिर्लब्धा^२ प्रश्नासुभ्योऽश्वः^३ शोध्याः^४ ॥ १८ ॥

१७. (घ) १. रूनयुताः (ग) रूनयुताः (क) (ख) नूनयुता for (सूनयुता)

२. + १७६५, १६३५, १६३५, १३६५, १६०० +

३. क्रमोत्क्रमन्यस्ताः (ग) (क) क्रमोत्क्रमास्ते (ख) क्रमोक्रमन्यस्ताः for (क्रमोक्रमन्यस्ताः)

(ग) २. यहाँ कोई संख्या नहीं दी गई ।

(ख) ४. स्वचरासुभिः for (स्वचरासुभिः)

५. क्रमाक्रमो for (क्रमोत्क्रमस्थै)

६. : विसर्गं लुप्त है

७. श्चार्कं for (श्चार्कं)

८. 'कृत्वा' पद लुप्त है ।

(च) १. रूनयुताः for (सूनयुता)

३. क्रमोत्क्रमन्यस्ताः for (क्रमोक्रमन्यस्ताः)

७. चाङ्क for (चार्क)

१८. (घ) १. श्वशोध्याः for (ऽश्वःशोध्याः) (ग) सवः (क) ऽसवः (ख) सर्व for (ऽश्वः)

२. + १८००(ख) + : +

(ग) ३. भुक्त्याराशेः (ख) for (भुक्त्याराशेः)

४. + १६७०, १७६५, १६३५, १६३५, १७६५, १६७० +

५. लब्धम् १८०० for (लब्धा) (क) लब्धाः for (लब्धा)

(क) ६. रविभुक्तहीनाराशेः for (रविणा भुक्त्याराशेः)

(ख) ७. गुणा for (गुणाः)

८. सुभिः भक्ताः for (सुभिर्भक्ताः)

(च) ६. ६ + १७६५

२ + १८०० +

१६३५

१६३५

१३६५

१५०० +

१०. अवग्रहचिह्नलुप्त

प्रक्षिप्य^६ राशय^२ भुवतं^३ शेषां^४ सुभ्यः^५ क्रमेण^६ यावतः^७ ।
 शुद्धत्फदया^१ सूर्ये^२ तावन्तो^३ राशयः^४ क्षेप्याः^५ ॥ १९ ॥
 शेषां^१ त्रिंशत्^२ गुणितानस्तन^३ शुद्धोदया^४ सुभिर्विभजेत्^५ ।
 लब्धभागादिरवौ^६ प्रक्षिप्य^७ तथा^८ कृते^९ लग्नम्^{१०} ॥ २० ॥

१९. (घ) १. शुध्यन्तु (ग) शुध्यन्त्युदयाः (क) शुध्यन्त्युदयाः (ख) for (शुद्धत्फदया)

- (ज) २. राश for (राश्य)
 ३. क्रमेण for (क्रमेण)
 ४. यावतः for (यावन्त)
 ५. 'क्षेप्याः' पदलुप्त है ।

(च) ६. +१७९५ } पिछले श्लोक के फुटनोट में संख्याएं दर्शा दी गई हैं ।
 १८३५
 १८३५
 १३९५
 १५०९

१. शुद्धन्त्युदयाः for (शुद्धत्फदया)

२०. (घ) १. शेषांस्तृंशद् (ग) शेषांस्त्रिंशद् for (शेषांस्त्रिंशत्)
 २. गुणिताः स्थेनस्तन for (गुणितानस्तन) (ग) नसून for (नस्तन)
 (क) दविशुद्धस्योदयाः for (नस्तनशुद्धोदया)

(क) ३. प्रक्षेप्यं for (प्रक्षिप्य)

(ख) १. शेषास्त्रिंशद्गुणा for (शेषांस्त्रिंशत् गुणिता)
 २. तसून for (नस्तन)
 ४. शुद्धासुभि for (शुद्धोदयासुभिर्)
 ५. वित्तजेत् for (विभजेत्)
 ६. लब्धा for (लब्ध)

(च) १. शेषांस्त्रिंशद्गुणिताः ३० नस्तन for (शेषां त्रिंशत् गुणितानस्तन)
 ७. क्रम संख्या लुप्त

रविराशयभुक्तलिप्तास्तद्वदय गुणिता हता ग्रहकलाभिः १८०० ।

लब्धं प्राणास्थाप्याः प्रक्षिप्याकं ग्रहाभुक्तम् ॥ २१ ॥

तावत्सूर्यो राशिं न क्षिपेत्समो लग्नराशिभिर्यावत् ।

क्षिप्रग्रहाणां प्राणान् प्रक्षिप्य स्थापितेष्वसुषु ॥ २२ ॥

तदधिककालोदयवधराशि कलाभिर्भजेत् फलं प्राणान् ।

प्रक्षिप्य प्राणेषु प्राणाः सूर्योदयादसकृत् ॥ २३ ॥

२१. (घ) १. हतो (क) हता (ख) कृता for (हतो)
 २. ग्रहकलाभिः (ग) (क) (ख) ग्रहकालाभिः for (ग्रहकलाभिः)
 ३. ग्रहाभुक्तम् (ग) (क) (ख) ग्रहामुक्तम् for (ग्रहाभुक्तम्)
 ४. रविराशयभुक्त (ग) (क) (ख) रविराशिभुक्त for (रविराशयभुक्त)
 (ग) ५. लब्धप्राणाः (ख) लब्धां प्राणाः for (लब्धप्राणा)
 (क) ६. प्राणाः (ख) प्राणः for (प्राणा)
 (च) ४. रविराशयभुक्त for (रविराशयभुक्त) १ हता for (हता) २ ग्रह for (ग्रह)
 ६. प्राणाः for (प्राणा) ३. ग्रहा for (ग्रहा)
२२. (ख) १. राशीन् (क) (ख) राशी for (राशिन)
 २. क्षिप्रग्रहाणां (ग) क्षिप्रगृहाणां (क) क्षिप्रग्रहाणां for (क्षिप्रग्रहाणां)
 (क) ३. समं for (समो)
 (ख) ४. 'न' लुप्त
 ५. यावत् for (यावत्)
 २. क्षिप्रग्रहाणां for (क्षिप्रग्रहाणां)
 (च) १. राशीन् for (राशिन) २. ग्रहाणां for (ग्रहाणां)
 ६. स्थापितेष्वसुषुः for (स्थापितेष्वसुषु)
२३. (घ) १. कलोदय (ग) (क) (ख) कलोदय (च) for (कालोदय)
 २. प्राणात् for (प्राणान्)
 (ग) ३. वधं (क) (ख) for (वध)
 ४. भजेजेत् for (भंजेत्)
 ५. प्राणाः (ख) for (प्राणाः)
 (क) ६. फलप्राणान् (ख) फलप्राणान् for (फलप्राणान्)
 ७. (.....) ॥ २३ ॥
 (ख) ८. राशिभिर्यावत् क्षिप्य ग्रहाणां प्राणान्प्रभिभजेत् for (राशिकलाभिर्भजेत्
 फलं प्राणान्)
 ९. प्राणेषु for (प्राणेषु)

प्रागुदयैः प्रश्नासुभिर्हूनोर्को भुक्तराशिभिर्लग्नम् ।
 कृत्वैवमूनमर्कं लग्नसमं प्राग्भवेत्कालः ॥ २४ ॥
 गतशेषाल्पस्याह्नः सौम्योत्तरगोलयोश्चराद्धं न ।
 ऊनाधिकस्य जीवा स्वाहोरात्र्याद्धं संगुणिता ॥ २५ ॥
 त्रिज्याहता युतोना क्षितिज्यया सौम्ययाम्ययोद्धेदः ।
 छेदोवलम्बकगुणो व्यासाद्धं विभाजितः शंकुः ॥ २६ ॥

२४. (घ) १. भुक्तः (ग) भुक्ति for (भुक्त)

(ग) २. प्रश्नासुभि for (प्रश्नासुभि)

३. मूनमर्कं (ख) मूनमर्कलग्नसमं for (मूनमर्कं लग्नसमं)

(ख) ४. हूनोको for (हूनोर्को)

५. लग्नम् for (लग्नम्)

६. कलः for (कालः)

(च) ४. हूनोर्को for (हूनोर्को) मवर्कं for (मर्कं)

२५. (घ) १. गत शेषाल्पस्याह्नः (ग) गतशेषाल्पस्याह्नः for (गतशेषाल्पस्याह्नः)

२. सौम्येतर (ग) (क) (ख) सौम्येतर for (सौम्योत्तर)

(ग) ३. रात्राद्धं (क) (ख) (च) for रात्र्याद्धं)

(क) १. गतशेषाल्पस्याह्नः (ख) गतशेषाल्पस्याह्नाः for (गतशेषाल्पस्याह्नः)

(ख) ४. चराद्धं for (चराद्धं)

५. ऊनाधिकस्य for (ऊनाधिकस्य)

(च) १. गतशेषाल्पस्याह्नः for (गतशेषाल्पस्याह्नः) २. सौम्येतर for (सौम्योत्तर)

२६. (घ) १. विभाजितशंकुः (च) for (विभाजितःशंकुः)

२. त्रिज्याहता (च) for (त्रिज्याहता)

३. छेदावलम्बकगुणो (च) for (छेदावलम्बकगुणो)

(ग) ४. छेद (क) याम्ययोद्धेदः (ख) for (याम्ययोद्धेदः)

(ख) ५. व्यासाद्धं for (व्यासाद्धं)

विषुवत्कर्णविभक्तः^१ छेदो वा द्वादशाहतः^३ शंकुः ।
 शकु^२कृतिविहीनाया व्यासाद्ध^३कृतेः पदं^४ दृग्ज्या ॥ २७ ॥
 दृग्ज्या द्वादश गुणिता^३ विभाजिता शंकुना^१ फल छाया ।
 व्यासाद्ध^४ छेदहतं विषुवत्कर्णहतं^५ कर्णः ॥ २८ ॥
 गुणितं वा द्वादशभिर्व्यासाद्धं^२ शंकुनाहतं^१ कर्णः ।
 जीवा क्षयवृद्धिज्यायुतहीना ज्या क्रियतुलादौ ॥ २९ ॥

२७. (घ) १. विभक्तं (च) for (विभक्तः)

२. शंकुकृतिविहीनाया (ग) (क) (ख) for (शकु^२कृतिविहीनाया)

(क) ३. हतः (ख) हतशंकुः for (हतःशंकुः)

(ख) ४. फलं दृग्जा for (पदं^४दृग्ज्या)

(च) द्वादशहतः for (द्वादशाहतः)

२. शंकुकृतिविहीनाया for (शंकुकृतिविहीनाया)

२८. (घ) १. फलं (ग) (क) (ख) फलं for (फल)

२. कर्णं for (कर्णः)

३. +१२ + (च) +१२ +

(ग) ४. व्यासाद्ध^४छेदहतं for (व्यासाद्धं^४ छेदहतं)

(क) ५. हतं (च) for (हतं)

(ख) ७. शंकुला for (शंकुना)

२९. (घ) १. हतं for (हतं) (ग) (क) (ख) हतकर्णं for (हतंकर्णः)

(क) २. व्यासाद्धं (ख) व्यासार्धं for (व्यासाद्धं)

(ख) ३. जा for (ज्या)

स्वाहोरात्र्यद्ध^१ गुणा^७ व्यासार्द्ध^२ विभाजिताऽथवा छेदः ।

शंक्वादि प्राग्वज्ज्या स्वाहोरात्र्यद्ध^३ धातु^४ कृता ॥ ३० ॥

व्यासार्द्धकृति^१ गुणिता^२ विषुवत्करणेन^३ वा भवेत्करणः ।

लम्बगुणो धातुः शंकु^४ व्यासार्द्धकृतिभक्तः ॥ ३१ ॥

३०. (घ) १. रात्रार्द्ध (ग) (क) (ख) रात्रार्ध for (रात्र्यद्ध)

२. व्यासार्ध (ग) (ख) for (व्यासार्द्ध)

३. रार्द्ध (ग) (क) रात्रार्ध (ख) for (रात्र्यद्ध)

४. हृता (ग) (क) हृता (ख) हृता for (कृता)

(ग) ५. धातु (क) (ख) for (धातु)

६. शंक्वादि for (शंक्वादि)

(ख) ७. गुण for (गुणा)

(च) १. रात्रार्द्ध for (रात्र्यद्ध) ४. हृता for (कृता)

३१. (घ) १. व्यासार्द्धकृति १०६६२६०० (ग) व्यासार्द्धकृति १०६६२६०० for (व्यासार्द्धकृति)

२. गुणिता (ग) (क) (च) for (गुणिता)

३. भवति (ग) (क) (ख) (च) for (भवेत्)

४. व्याघातः (ग) (क) वा धातुः (ख) वाघतः for (धातुः)

५. कृतिवक्तः (ग) कृतिभुक्तः for (भक्तः)

(ग) ६. शंकुव्यासार्द्ध (क) (ख) शंकुव्यासार्ध for (शंकुव्यासार्द्ध)

(ख) १. व्यासार्द्धकृति १०६६२६०० for (व्यासार्द्धकृति) २. गुणिता for (गुणिता)

४. व्याघातः for (धातुः)

घातोवार्कगुणा १२ स्त्रिज्या विषुवत्कर्णबंधः हतः शंकुः ।
 कर्णकृते संशोध्य द्वादशवर्ग १४४ पदं छाया ॥ ३२ ॥
 अल्पप्रश्नासूनां यदि बहवश्चरदलासवः क्षितिजा ।
 हतयोना जोवोना क्षयवृद्धिज्योक्तवच्छेष ॥ ३३ ॥
 स्वाहोरात्रार्द्धमुदकदक्षिणयोः क्षितिज्यया युतविहीनं ।
 द्युदलान्त्यज्याभिज्य क्षयवृद्धिज्या युतोनांत्या ॥ ३४ ॥

३२. (घ) १. कर्णः (च) for (कर्ण)
 २. वधः (ग) वध (क) for (बंधः) (ख) 'बंध' पद लुप्त है ।
 ३. हतः (ग) (क) (च) for (हतः)
 (ग) ४. गुणस्त्रिज्या (क) (ख) for (कृते)
 ५. कृतेः (क) (ख) गुणस्त्रिज्या for (गुणा १२ स्त्रिज्या)
 ६. छायाः for (छाया)
 (क) संख्याएँ मूल में अंकित नहीं हैं ।
 (ख) ७. संशोध्या for (संशोध्य)
 ८. वर्गगयछाया for (वर्ग १४४ पदं छाया)
 (च) ४. घातोवार्कगुणा १२ for (घातोवार्कगुणा १२) २. वधः for (बंधः)
 १. कर्णः for (कर्ण)

३३. (घ) १. हतयोना (ग) (च) for (हतयोना)
 (ग) २. अल्पप्रश्नासूना for (अल्पप्रश्नासूना)
 (क) मूल श्लोक अंकित नहीं है—केवल टीका लिखी हुई है ।
 (ख) ३. छाषम् for (छेषम्)

३४. (घ) १. उदग्दक्षिणयोः (ग) स्वाहोरात्रार्द्धमुदग्दक्षिणयोः (ख) for (स्वाहोरात्रार्द्धमुद-
 कदक्षिणयोः)
 (ग) २. द्युदलान्त्यज्या for (द्युदलान्त्यज्या)
 ३. त्रिज्या (क) (ख) त्रिज्या (च) for (भिज्या)
 ४. वृध्य for (वृद्धिज्या)
 ५. नांत्याः for (नांत्या)
 (क) १. स्वाहोरात्रार्द्धमुदग्दक्षिणयोः for (स्वाहोरात्रार्द्धमुदकदक्षिणयोः)
 ६. क्षितिजया (ख) क्षितिज्यया for (क्षितिज्यया)
 (च) १. मुदग्दक्षिणयोः for (मुदकदक्षिणयोः)

छेदहता^१ द्युदला^२न्त्या दिना^३द्धं कर्ण^४ेन वा कर्णः^५ ।

भक्ता^१ ज्यया^२ ऽथवा^३ऽन्त्या दिना^४द्धं कर्ण^५ा हुता^६ कर्णः^७ ॥ ३५ ॥

द्युदलान्नतो^१ क्रमज्या^२ स्वाहोरात्र्या^३द्धं संगुण^४ विभजेत् ।

व्यासा^१द्धं न फलोना^२ द्युदलान्त्यया^३थवा छेदः^४ ॥ ३६ ॥

अन्त्यानतो^१ क्रमज्या^२ हीनां^३ ज्या षट्^४ पृथक्^५ छेदः^६ ।

ज्याभ्यां^१ च सह^२ फलानि^३ छाया^४ नयनानि^५ षट्^६ त्रिंशत्^७ ॥ ३७ ॥

३५. (घ) २. वा गुणा for (वा) (ग) संगुणा for (वा) (क) संगुणा for (वा) (ख)
कर्णः for (वाकर्णः)

१. छेदहता (ग) (क) (च) for (छेदहता)
(ग) ३. कर्णहता (क) कर्णहिता (ख) कर्णः हुता for (कर्णहिता)
(ख) ४. नवागुणाः for (द्विकर्णेन)
(च) २. वागुणाकर्णः for (वाकर्णः)

३६. (घ) १. द्युदलान्ततोत्क्रमज्यां (ग) (क) (च) for (द्युदलान्नतो क्रमज्या)
२. स्वाहोरात्रार्धं संगुणं विभजेत् । (ग) स्वाहोरात्रार्धसंगुणं विभजेत् for
(स्वाहोरात्र्याद्धं संगुणा विभजेत्)
३. दलान्त्य ज्याथवा for (द्युदलान्त्ययाथवा)

(ग) ३. दलान्त्यज्या यथा (क) द्युदलान्त्यज्याथवा (ख) for (द्युदलान्त्ययाथवा)
(क) ४. संगुणाम् (ख) संगुणं for संगुणा
(ख) १. द्युदलान्नतोत्क्रमजां for (द्युदलान्नतो क्रमज्या)
२. स्वाहोरात्रार्धं for (स्वाहोरात्र्याद्धं)
५. फलेना for (फलोना)
(च) २. स्वाहोरात्रार्धं for (स्वाहोरात्र्याद्धं)
४. संगुणां for (संगुणा)

३७. (घ) १. अन्त्यानतोत्क्रमज्याहीना (ग) (क) (ख) for (अन्त्यानतो क्रमज्याहीनां)
३. छेदाः (ग) (ख) छेदा for (छेदः)

(च) ४. 'च' अतिरिक्त पाठ
५. फलनि for (फलानि)
६. षट्त्रिंशत् for (षट्त्रिंशत्)
(च) १. अन्त्यानतोत्क्रमज्याहीन for (अन्त्यानतो क्रमज्याहीनां) ३ छेदाः for (छेदः)

छाया कर्णविभक्ता^४ विषुवत्कर्णेन^५ संगुणा^२ नृज्या^१ ।
 लब्धं सौम्येतरयोः^५ क्षितिज्यया^३ हीनसंयुक्तं^३ ॥ ३८ ॥
 गुणितं व्यासाद्धेन^१ स्वाहोरात्राद्धेन^२ भक्तमातधनुः^३ ।
 उत्तर गोले युक्तं^३ याम्ये^४ हीनं^३ चरप्राणैः^३ ॥ ३९ ॥
 दिनगतशेषछेदप्राणाः^३ प्राणपरदिनाद्धेन^२ विशोध्यमातम्^३ ।
 व्यासाद्धेन^१ छेषो^५ क्रमजीवा^४ चापं^३ नताः^२ प्राणाः^३ ॥ ४० ॥
 स्वाहोरात्राद्धेन^१ छायाकर्णा^२ हतेन^३ भक्ताया^३ ।
 विषुवत्कर्णं^३ गुणाय^४ व्यासाद्धेन^५ कृतेः^३ फलं^३ सौम्ये^३ ॥ ४१ ॥

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३८. (ग) १. त्रिज्या (क) (ख) त्रिज्या for (नृज्या)
 (क) २. संगुण for (संगुणा)
 ३. संयुतम् (ख) for (संयुक्तं)
 (ख) ४. विभक्त for (विभक्ता)
 ५. सौम्येतरयो for (सौम्येतरयोः)
 ६. ज्याया for (ज्यया)
३९. (ख) १. रात्राद्धेन for (रात्राद्धेन)
 २. भक्तमातधनुः for (भक्तमातधनुः)
 ३. प्राणै for (प्राणैः)
४०. (घ) १. व्यासाद्धेनोत्क्रम (ग) व्यासाद्धेनोत्क्रमोत्क्रम for (व्यासाद्धेनोत्क्रम)
 २. नता (क) नत for (नताः)
 (ग) ३. शेषप्राणाः (क) शेषप्राणाः for (शेषछेद प्राणाः)
 (क) ४. 'छेद' पद लुप्त है । (ख)
 ५. शेषोत्क्रम (ख) छेदोत्क्रम for (छेषोत्क्रम)
 (ख) ६. विशोध्यमातम् for (विशोध्यमातम्)
 (च) १. व्यासाद्धेनोत्क्रम for (व्यासाद्धेनोत्क्रम)
४१. (ग) १. भक्तायाः (क) (ख) for (भक्ताया)
 (ख) २. कर्णाहतेन for (कर्णाहतेन)
 (ख) ३. विषुवत्कर्ण for (विषुवत्कर्ण)
 ४. गुणाय for (गुणाय)
 ५. कृते for (कृतेः)

क्षयवृद्धिज्याहीनं युक्तं याम्ये^२ धनुश्चर^३प्राणैः^४ ।
 सौम्येयुतं विहीनं याम्ये प्रागपरयोः प्राणाः ॥ ४२ ॥
 अह्नोगताऽवशेषाः फलमन्त्याया विशोध्य शेषस्य ।
 धनुश्क्रमजीवाभिः पूर्वापरयोर्नताः प्राणाः ॥ ४३ ॥
 दिनदलकण^३गुणांत्या छायाकर्णाद्धृता फलोनान्या^२ ।
 शेषस्योत्क्रमजीवा धनुदिनाद्ध^१नताः प्राणाः ॥ ४४ ॥
 चरदल जीवोनाधिक फल क्रमज्यो धनुश्चराद्धेन^१ ।
 युतहीन पूर्वाह्ने^३ दिवसगतं शेष^२ अपराद्धे ॥ ४५ ॥

४२. (क) १. प्राणैः (ख) प्राणः for (प्राणः)

(ख) २. याम्यो for (याम्ये)

३. धनुश्चर for (धनुश्चर)

४. प्राणैः for (प्राणैः)

५. प्रागपरयोः for (प्रागपरयोः)

४३. (घ) १. धनुश्क्रमजीवाभिः (ग) (क) (ख) (च) for (धनुश्क्रमजीवाभिः)

(ग) १. नता (क) नत for (नताः)

(क) ३. अह्नोगतावशेषात् (ख) अह्नोगतावशेषा for (अह्नोगताऽवशेषाः)

(ख) ४. प्राणः for (प्राणाः)

(च) ३. अवग्रहचिह्नं लुप्त

४४. (घ) १. दिनाद्वाप्तताः for (दिनाद्धनताः) (ग) (क) दिनाद्धनत for (दिनाद्धनताः)

(ग) २. नान्त्या (ख) नान्त्या for (नान्त्या)

(ख) ३. गुणांत्या

४. कर्णाद्धृता for (कर्णाद्धृता)

५. जीव for (जीवा)

१. दिनार्धोन्नतप्राणः for (दिनाद्धनताः प्राणाः)

(च) १. धनुर्दिनाद्धनताः for (धनुदिनाद्धनताः)

४५. (घ) १. क्रमज्या (ग) (क) (ख) क्रमज्या for (क्रमज्यो)

२. शेषमपराह्णे (ग) (ख) शेषमपराह्णे (च) for (शेषं अपराह्णे)

(ग) ३. पूर्वाह्णे (ख) पूर्वाह्णे for (पूर्वाह्णे)

(ख) ४. विवसगतं for (दिवसगतं)

उत्क्रमजीवोभ्यधिक क्रमज्यया संयुक्तं^४ (तं) धनुर्धनुषां^१ ।
 व्यस्तविशुद्धौ^५ हीनाश्चरांसवः^२ पूर्ववच्छेषं^३ ॥ ४६ ॥
 दिनमध्यार्का^१ क्रांत्याक्षभागयोगांतरं^५ सामान्यदिशोः ।
 नतभागा^६ नवते प्राक्^५ ज्योन्नताः^३ शेषाः^१ ॥ ४७ ॥
 नतभागज्या द्वादशगुणोन्नतांशज्यया^५ हताल्लब्धम्^१ ।
 इष्टदिनार्द्धाया^३ यथोक्तकरणैर्दिनार्द्धा^३ ॥ ४८ ॥

४६. (घ) १. संयुतम् (ग) (क) (ख) संयुते for (संयुक्तं)
 २. चरांसवः (ग) (क) (ख) (च) for (चरांसवः)
 ३. पूर्ववच्छेषं (ग) पूर्ववत्सेषम् for (पूर्ववच्छेषं)
 ५. व्यक्त for (व्यस्त)
- (ज) १. संयुतं for (संयुक्तं) ६. धनुर्धनुषा for (धनुर्धनुषां)
४७. (घ) १. दिनमध्यार्का (ग) (क) (ख) for (दिनमध्यार्का)
 २. क्रांत्याक्ष (ग) (क) (ख) for (क्रांत्याक्ष)
 ६. नतभागानतभागनवते १० (ग) नतभागानतभागान्नवते: for (नतभागानवते)
 ३. प्रोन्नताः (ख) प्रोज्योन्नतभागास्तु for (ज्योन्नताः)
- (ग) ४. सामान्यदिशोः (क) समानदिशोः (ख) समान्यादिशोः for (सामान्यदिशोः)
 ५. प्रोन्नतोन्नताः शेषा (क) (ख) देखो ३. for (प्राक्ज्योन्नताः शेषाः)
- (क) ६. नतभागा नतभागोन्नवते: (ख) नतभागान्नवते: for (नतभागानवते)
 (ख) ७. शाय्याः स्युः for (शेषाः)
- (च) १. दिनमध्यार्का for (दिनमध्यार्का)
 २. क्रांत्याक्ष for (क्रांत्याक्ष)
 ४. सामान्यदिशोः for (सामान्यदिशोः)
 ६. नतभागानतभागान्नवते १० for (नतभागानवते)
४८. (घ) १. हूता (ग) (क) (ख) हताल्लब्धम् for (हताल्लब्धम्)
 २. करणौ (ख) करणे for (करणौ)
 ३. दिनार्धा (ग) दिनार्द्धाद्वा (क) दिनार्धाद्वा for (दिनार्द्धाद्वा)
- (ग) ४. द्वादशगुणोन्नतांश (ख) द्वादशगुणोन्नतांश for (द्वादशगुणोन्नतांश)
 (ख) ५. ज्याया for (ज्यया)
 ३. दिनार्द्धाद्वा for (दिनार्द्धाद्वा)
- (च) १. हताल्लब्ध for (हताल्लब्धम्)
 २. करणौ for (करणौ) ३. दिनार्द्धा for (दिनार्द्धाद्वा)

उन्नतजीवाभक्तं^४ व्यासार्द्धं^५ द्वादशाहतं^३ कर्णः ।
 मध्यछायाकर्णं^१ द्वादशक्रान्त्यतरं^२ पदं वा ॥ ४९ ॥
 कुदलांत्याज्या^२ छेदोमध्यछाया^१ यथोक्तकरणैर्वा ।
 अन्त्याज्या^४ छेदाद्यैर्मध्यछाया^५स्यवा बहुधा । ५० ॥
 विषुवत्करणेन^६ गुणा विषुवच्छाया^७ हतोत्तरा क्रान्तिः ।
 यद्युनाक्षज्याया^८ शंकुसममंडलस्थेऽर्के^९ ॥ ५१ ॥

४९. (घ) १. छायां for (छाया)
 २. कृत्यन्तरपदम् (ग) (क) कृत्यन्तरपदं वा for (क्रान्त्यतरं पदं वा)
 ३. द्वादशाहतं ११ for (द्वादशाहतं)
 (ग) ४. भुक्तं for (भक्तं)
 (ख) ५. व्यासार्धं for (व्यासार्द्धं)
 १. 'मध्यछायाकर्णं' पद लुप्त है ।
 २. कृत्यन्तर for (क्रान्त्यतर) यहां दूसरी पंक्ति 'द्वादश' से आरम्भ है ।
 (च) १. छायां for (छाया) २. कृत्यन्तरपदं वा for (क्रान्त्यतरं पदं वा)
 ५०. (घ) १. कुदलां (ग) (क) (ख) (च) for (कुदलां)
 (ग) २. त्याज्या (क) (ख) for (त्याज्या)
 ३. वरणैर्वा (ख) करणै वाः for (करणैर्वा)
 (क) ४. अन्त्याज्या (ख) अत्याज्याः for (अन्त्याज्या)
 (ख) ५. मध्यछाया for (मध्यछाया)
 (च) ६. अवग्रह चिह्न लुप्त
 ५१. (घ) १. विषुवच्छाया (ग) (ख) विषुवच्छाया for (विषुवच्छाया)
 २. हतोत्तरा for (हतोत्तरा) (क) छायादृतोत्तरा for (छायाहतोत्तरा)
 ३. यद्युनाक्षज्याया (ग) यदुनाक्षज्यायाः (क) यद्युनाक्षज्यायाः for (यद्युनाक्ष-
 क्षज्याया)
 ४. समं (च) for (सम)
 (ग) ५. शंकुः (क) (ख) 'शंकु' लुप्त पद for (शंकु)
 (क) ६. विषुवत्करणेन for (विषुवत्करणेन)
 ३. यद्युनाक्षज्यायाः for (यद्युनाक्षज्याया)
 ७. मंडलस्थेऽर्के for (मंडलस्थे ऽर्के)
 (च) १. विषुवच्छाया for (विषुवच्छाया)
 २. हतोत्तरा for (हतोत्तरा) ३. यद्युनाक्षज्याया for (यद्युनाक्षज्याया)

सूर्यज्या^३ जिनभागज्याया^५ गुणाक्षज्याया^६स्थवा^१ भक्ता ।
 अग्रा^७ द्वादशगुणिता विषुवच्छाया विभक्ता वा ॥ ५२ ॥
 द्वादश विषुवच्छाया गुणिता पृथगक्षलंबजीवे वा ।
 क्रान्तिहते^२ सममण्डलकर्णो^५ प्राग्दत् पृथक् छाया^३ ॥ ५३ ॥
 अक्राग्रा^८ वर्गोनं^६ नृज्या^१ वर्गार्धं^५ ५३४६४५० मर्क^२ १४४ कृतिगुणितं ।
 आद्यान्योग्रा^३ द्वादशविषुवच्छाया^५ वधो^१ हृतयोः ॥ ५४ ॥

५२. (घ) १. ज्ययाथवा (च) for (ज्ययास्थवा)
 २. विषुवच्छाया (ग) for (विषुवच्छाया)
 (ग) ३. दिनभागज्यागुणा for (जिनभागज्याया गुणा) (ख)
 (क) ४. अग्रात् (ख) अग्र for (अग्रा)
 (ख) ५. गुणाक्षयाथवा for (गुणाक्षज्यायास्थवा)
 ६. 'ज्यया' लुप्त पद है ।
 ७. विभक्त for (विभक्ता)
 (च) २. विषुवच्छाया for (विषुवच्छाया)
५३. (घ) १. विषुवच्छाया (ग) (च) for (विषुवच्छाया)
 २. हते (ग) (क) (च) for (हते)
 ३. छाये for (छाया) (ग) (ख) पृथकार्ये for (पृथक् छाया)
 (ख) ४. पृथगक्ष for (पृथगक्ष)
 ५. कर्णो for (कर्णो)
 (च) ३. छायो for (छाया)
५४. (घ) १. वर्गार्धं ५३४६४५० for (वर्गार्धं ५३४६४५०) (ग) वर्गार्धं (ख) वर्गो for (वर्गार्धं)
 २. मर्ककृतिगुणितं १४४ (ख) धर्मकृति for (मर्क १४४ कृतिगुणितं)
 ३. आद्यान्योग्रा (ग) (क) (ख) आद्यान्योग्रा (च) for (आद्यान्योग्रा)
 ४. विषुवच्छाया (ग) (च) for (विषुवच्छाया)
 ५. हृतयोः (ग) (क) (ख) हृतयो for (हृतयोः)
 (ग) ६. वर्गोनं for (वर्गोनं)
 ७. त्रिज्या (क) (ख) for (नृज्या)
 वि० श्लोक में दी गई संस्थाएं इस प्रति में नहीं हैं ।
 (क) १. वर्गार्धमर्क कृति for (वर्गार्धं ५३४६४५० मर्क १४४ कृति)
 (च) ८. अक्राग्रा for (अक्राग्रा) ६ वर्गोनं for (वर्गोनं)
 १. वर्गार्धं ५३४६४५० for (वर्गार्धं ५३४६४५०) २ मर्क कृतिगुणितं १४४ for (मर्क १४४ कृति गुणितं)
 ५. हृतयोः for (हृतयोः)

विषुवच्छाया कृत्याद्वा संगयुतया ७२ न्यकृतियुतादाद्यात् ।

पदमन्ययुतविहीनं सौम्येत्तरगोलयोः शंकुः ॥ ५५ ॥

विदिशोः सौम्येत्तरयोस्तत्तरगोले पदोनयुक्तो न्यः ।

सममण्डल दक्षिणतोतच्छाया नाडिकाः प्राग्वत् ॥ ५६ ॥

प्राच्यपरा शंकुतलान्तरद्वयव्यस्तकर्णवर्धविवरं ।

समदिग्विषुवत्छायान्यदिगैक्यं कर्णविवरहतम् ॥ ५७ ॥

५५. (घ) १. विषुवच्छाया, (ग) for (विषुवच्छाया)

२. गसंयुतया ७२ for (संगयुतया ७२)

(ख) ३. कृत्याः व्यागसंयुतया for (कृत्याद्वा संगयुतया ७२)

(ग) ३. कृत्याद्वचग ७२ संयुतया (क) for (कृत्या द्वासंगयुतया)

४. परमन्ययुत (ख) पदमन्ययुतं for (पदमन्ययुत)

(ख) ६. युतयाद्यात् for (युतादाद्यात्)

(च) १. विषुवच्छाया for (विषुवच्छाया) २. गसंयुतया ७२ for (संगयुतया ७२)

५६. (घ) १. विदिशो सौम्येत्तरयो (ग) विदिशो सौम्येत्तरयो (क) for (विदिशोः सौम्ये-
तरयो)

२. रुत्तरागोले (क) रुत्तरागोले for (रुत्तरगोले) (ख) गोपदोन for (गोलेप-
दोन)

३. तच्छाया (क) नच्छाया (ख) तच्छाया for (तच्छाया)

(ग) ४. दक्षिणागतच्छाया (क) दक्षिणगे (ख) दक्षिणगो for (दक्षिणतो)

(क) ५. न्यः । (ख) युक्ता यः for (युक्तोन्यः)

(ख) १. वेदि for (विदिशोः)

६. शौम्येत्तरयो for (शौम्येत्तरयो)

७. नाडिका for (नाडिकाः)

(च) १. विदिशो for (विदिशोः) ३. तच्छाया for (तच्छाया)

५७. (घ) १. विषुवच्छाया (ग) (क) विषुवच्छाया for (विषुवच्छाया)

२. कर्णविवरहतम् (ग) कर्णविवरहतम् for (कर्णविवरहतम्)

३. यात्यपरा (ग) प्राच्यापरा for (प्राच्यपरा)

(च) १. विषुवच्छाया for (विषुवच्छाया) २. कर्णविवरहतम् for (कर्णविवरहतं)

छायावृत्तागोमा^३ सौम्येन युगान्तरेण^५ याम्येन ।
 विषुवच्छायाज्जादिषु^२ तुलादिषु^४ तथान्तरं^१ हीनं ॥ ५८ ॥
 इष्टाछाया वृत्ते^१ तदग्रयो^२ यदुदयास्तमयसूत्रम् ।
 अनुपातात्^३ छंको^४ विषुवत्छायांतरमिहग्रा^५ ॥ ५९ ॥
 शंकुप्राच्यपरान्तरविषुवत्छायां^१ऽगुलांतरं^२ याम्ये ।
 उदगैक्यं^३ लम्बगुणं^४ छाया^५ कर्णाद्धूतं^६ क्रान्तिः ॥ ६० ॥

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५८. (घ) १. विषुवच्छाया (ग) (च) for (विषुवच्छाया)
 २. जादिषु (क) (च) for (ज्जादिषु)
 (ग) ३. गोमा (क) for (गोमा)
 ४. तथान्तरं for (तथान्तरं)
 (क) ५. युगान्तरेण for (युगान्तरेण)
५९. (घ) १. अनुपातात्तच्छंको (ग) अनुपातात्तच्छंको for (अनुपातात्तच्छंको)
 २. विषुवच्छाया for (विषुवच्छाया) (ग) विषुवच्छायांतरमिहग्रा (क) for (विषु-
 वच्छायांतरमिहग्रा)
 ३. इहग्रा for (इहग्रा)
 ४. इष्टाछाया (ग) (क) for (इष्टाछाया)
 (ग) ५. तदग्रया for (तदग्रयो)
 (क) ६. यदुदयास्तमयं for (यदुदयास्तमय)
 (च) १. अनुपातात्तच्छंको for (अनुपातात्तच्छंको)
 २. विषुवच्छायांतर for (विषुवच्छायांतर)
 ३. मिहग्रा for (मिहग्रा)
६०. (घ) १. विषुवच्छायां for (विषुवच्छायां) (ग) (क) विषुवच्छायांतरं for (विषुवच्छा-
 यांऽगुलांतरं)
 २. छायांगुलांतरम् (ग) for (छायांगुलांतरं)
 ४. क्रान्ति for (क्रान्तिः)
 (क) १. विषुवच्छायां for (विषुवच्छायां) २. गुलांतरं for (गुलांतरं)

क्रान्तिव्यासार्द्धगुणा ३२७० जिनभागज्या १३२६४ हतातुरजादौ ।
 कर्कादौ चक्रार्द्धप्रोक्ततुलादौ स चक्रार्द्ध ॥६१॥
 चक्रात्प्रोह्य मृगादौ स्फुटौ सकृत् व्यस्तमृगं धनमध्यम् ।
 अर्कास्माद् देशान्तरयुगयाते मध्यमा प्राग्वत् ॥ ६२ ॥

६१. (घ) १. क्रान्तिव्यासार्द्ध गुणाः (ग) क्रान्तिव्यासार्द्ध गुणा (क) for (क्रान्तिव्यासार्द्ध गुणा)

२. कर्कादौ (ग) (क) (च) for (कर्कादौ)

३. प्रोक्ततुलादौ (ग) प्रोह्य (क) for (प्रोक्ततुलादौ)

४. वक्रार्धम् (क) चक्रार्द्ध (सभावेन) for (चक्रार्द्ध)

५. १३२६ for (१३२६४)

६. धनुरजादौ (ग) हता धनुरजादौ (क) for (हतातुरजादौ)

(च) १. क्रान्तिव्यासार्द्ध for (क्रान्तिव्यासार्द्ध)

७. गुणाः for (गुणा) ६. हता १३२६४ नुरजादौ for (१३२६४ हतातुरजादौ)

६२. (घ) १. प्रामृगादौ for (प्रोह्यमृगादौ) (क) ऽऽऽत्प्रास्य for (प्रोह्य)

२. अर्को (ग) (क) मध्यकोऽस्य for (अर्कास्माद्)

३. मध्यमाः for (मध्यमा)

४. मध्यः (ग) (च) for (मध्यम्)

(ग) ५. ऽसकृत् (क) ऽसकृद् for (सकृत्)

(क) ६. व्यस्तघनयुषं for (व्यस्तमृगंधनं) (च) मृग for (मृगं)

७. देशान्तरयुगया तेन for (देशान्तरयुगयाते)

(च) १. चक्रात्प्रोह्य for (चक्रात्प्रोह्य)

२. अर्कोऽस्मादेशान्तर for (अर्कास्माद्देशान्तर)

८. प्राग्वत् for (प्राग्वत्)

शशिमृगोन्यत्यर्थे^१ रात्रेर्गतशेषनाडिका^२ शंकु^३ ।
 विपरीतगोलविधिना^४ रात्र्यर्द्धा^५ क्रान्तिराभिर्वा ॥ ६३ ॥
 क्षितिजेऽग्रा प्राच्यपराक्रान्तिस्त्रिज्यागुणावलम्बहता^६ ।
 द्विगुणमुदयास्तसूत्रं^७ तत्त्रिज्या कृतिविशेषपदम् ॥ ६४ ॥
 अक्षज्या शंकुवधालम्बकलब्धोदयास्तमयसूत्रात् ।
 दक्षिणतः शंकुतलं दिवसो रात्रौ तदुत्तरतः ॥ ६५ ॥
 दिग्लम्बाक्षस्वोदयलग्नछायादिषु^८ यदिष्टेषु ।
 षट् षष्टचार्याणां त्रिप्रश्नाध्यायस्तृतीयोयम् ॥ ६६ ॥

इति ब्रह्मगुप्ते तृतीयोऽध्यायः

६३. (घ) १. शृगोन्यत्यर्थं (ग) शृगोन्यत्यर्थं (क) शृगोन्यत्यर्थं for (शशिमृगोन्यत्यर्थं)
 २. नाडिकाम् for (नाडिका)
 ३. शंकुः (ग) (क) for (शंकु)
 ४. रात्र्यर्धाक्रान्तिराभिर्वा (ग) क्रान्तिराभिर्वा (क) कोन्तराभिर्वा for (रात्र्य-
 र्द्धा क्रान्तिराभिर्वा)
 (ग) ५. विपरीतगोलविधि for (विपरीतगोलविधिना) (च) विपस्ति for (विपरीत)
 (च) १. शृगोन्यत्यर्थं for (शशिमृगोन्यत्यर्थं)
 ४. रात्र्यर्धाक्रान्तिराभिर्वा for (रात्र्यर्द्धाक्रान्तिराभिर्वा)
६४. (क) १. हता (क) (च) for (हता)
 (ग) २. गुणवलम्बहता for (गुणावलम्बहता)
 (क) ३. वियुक्तपदम् for (विशेषपदम्)
 (च) ४. सूत्रं for (सूत्रं)
६५. (घ) १. शंकुवधालम्बक for (शंकुवधालम्बक) (ग) (क)
 (ग) २. लब्धोदयास्तसूत्रात् for (लब्धोदयास्तमयसूत्रात्)
 (क) ३. शंकुः for (शंकु)
६६. (घ) १. दिग्लम्बाक्ष for (दिग्लम्बाक्ष)
 (ग) २. छायादिषूपदिष्टेषु (क) (च) for (छायादिषु यदिष्टेषु)
 ३. त्रिप्रश्नाध्यायः for (त्रिप्रश्नाध्यायस्)
 (क) ४. तृतीयोऽयम् for (तृतीयोयम्)
 (च) ४. तृतीयोयं ॥३॥ for (तृतीयोयं ॥६६॥)

वि० श्लोक क्रमांक ६६ के स्थानपर 'तीव' का अंक अध्याय की क्रम संख्या को दर्शाता है ।

कालज्ञानं प्रायः पर्वज्ञानार्थमिष्यते सद्भिः ।
 शशिभास्करग्रहणयोस्तद्भिः व्यक्तिः स्फुटामेदः ॥ १ ॥
 दिग्बर्णवलनवेलायां निमिलनोन्मीलनस्थितिविमर्दाः ।
 स्पर्श-छाया-मोक्ष-प्रासेष्ट-प्रास-परिलेखा ॥ २ ॥
 भेदाश्चतुर्दश तयोरिन्द्रकग्रहणयोः परिज्ञानात् ।
 यस्माद्भेदज्ञानं तस्माद् ग्रहणं प्रवक्ष्यामि ॥ ३ ॥
 तिथिगतगम्ये भुक्तिं भुत्तचंतरहते फलोनयुतौ ।
 रविशशिनौ समलिप्तौ यातस्तात्कालिको भवति ॥ ४ ॥

१. (घ) १. तदभिव्यक्तिः (ग) for (तद्भिव्यक्तिः)
- (क) १. स्वदभिव्यक्तिः for (तद्भिव्यक्तिः)
- (च) १. तदभिव्यक्तिः for (तद्भिव्यक्तिः)
२. (घ) १. खला निमीलानोन्मीलन (ग) वेला निमीलनोन्मीलन for (वेलायां निमिलनोन्मीलन)
- (क) मूलश्लोक यहाँ उपलब्ध नहीं, हाँ उसकी टीका दी हुई है ।
- (च) ३. निमीलनोन्मीलन for (निमिलनोन्मीलन)
३. (घ) १. परिज्ञानातः for (परिज्ञानात्)
२. ग्रहणो (ग) (क) for (ग्रहणं)
३. प्रविक्ष्यामि (ग) (क) प्रवक्ष्यामि for (प्रवक्ष्यामि)
- (ग) ४. भेदाश्चतुर्दश for (भेदाश्चतुर्दश)
५. ग्रहणयो for (ग्रहणयोः)
- (च) २. दग्रहणो for (दग्रहणं) ३ प्रविक्ष्यामि for (प्रवक्ष्यामि)
४. (घ) १. गुरोर्भुत्तचंतर for (भुत्तचंतर)
२. हते (क) (च) for (हते)
- (क) १. यहाँ 'भुक्ति' के आगे 'गुरो' अधिक पद है
३. पातस् (च) for (यातस्)
- (च) ४. +गुरो +

खत्रिघन (घन) गुणा व्यासाद्ध^४भाजिता ३२७० चन्द्रपातयोगज्या^३ ।
 विक्षेपकालाः सौम्याः षट् राश्यूनधिके याम्याः ॥ ५ ॥
 रविशशिभुक्ती भवदशगुरौ नख स्वरजिनैः हते^६ नात्ते^३ ।
 तत्त्वाष्टगुणितभुक्तयोर्विवरं षष्ट्याहृतं तमसः ॥ ६ ॥
 छाद्यं छादक मानैक्यार्थं विक्षेप हनिकं^२ हन्नं^३ ३३ ३३ ।
 सर्वग्रहणं ग्राह्यादधिके खण्डग्रहणमूने ॥ ७ ॥

५. (च) १. षट् राश्यूनधिके (ग) षट् राश्यूनधिके (क) षट् राश्यूनधिके for (षट् राश्यूनधिके)
 (ग) २. विभाजिता for (भाजिता)
 ३. ज्याः for (ज्या)
 ४. + २७० +
 ५. कलाः (क) for (कालाः)
 (च) ६. सौम्या for (सौम्याः)
 १. षट् राश्यूनधिके for (षट् राश्यूनधिके)
 ६. (घ) १. नखैः (क) (च) for (नखैः)
 २. हते (ग) (क) (च) for (हते)
 ३. माने (ग) (क) (च) for (नात्ते)
 ४. षष्ट्याहृतमंतरं तमसः (ग) षष्ट्याहृतं तमसः for (षष्ट्याहृतं तमसः)
 (ग) ५. गुरौः ११।१०। for (गुरौ)
 ६. जिनै २०।२४७ (क) जिनै for (जिनैः)
 ७. तत्त्वाष्ट २५।८ (क) तत्त्वाष्ट for (तत्त्वाष्ट)
 (क) ८. भुक्तयो विवरं for (भुक्तयोर्विवरं)
 ९. षष्ट्याहृतं for (षष्ट्याहृतं)
 ७. (घ) १. छाद्य-(ग) (क) for (छाद्यं)
 २. हनिकं (ग) (क) (च) for (हनिकं)
 ३. छन्नं । (ग) छिन्नम् (क) छन्नम् (च) for (हन्नं)
 ४. षण्ड (क) for (खण्ड)

(च) वि० इस श्लोक के बाईं ओर “११ | १० |” संख्यासारणी अंकित है ।
 २० | २४ |

छाद्य^४ने युतो^१नस्य छादक^१मानस्य तद्वलकृतिभ्याम् ।
 विक्षेपकृत्ति प्रोह्य पदेति व स्थिति विमर्दाद्ध^५ ॥ ८ ॥
 षष्ठ्या विभाजिता स्थितिविमर्दाद्ध^१नाडिका गुणाः स्वगतिः ।
 आदौ रविशशिपातेष्वृणमसकृतेषु धनमन्ते ॥ ९ ॥
 स्पर्शान्निमीलनं स्थितिदले विमर्दाद्ध^१हीनके पश्चात् ।
 मोक्षादवगुन्मीलनं विमर्द^२स्तयोरैक्यम् ॥ १० ॥
 भुत्तन्तरमिष्टोनस्थितिदलघटिका गुणहृतं षष्ठ्या ।
 बाहुः प्राग्वत् तत्फलहीनयुतैः सूर्यशशिः पातैः ॥ ११ ॥

८. (घ) १. छदक for (छादक)
 २. कृत्ति (ग) for (कृत्ति)
 ३. तिथिवत् (ग) (क) for (तिवस्थिति)
 (क) ४. युतोनास्य for (युतोनास्य)
 ५. विमर्दाधे for (विमर्दाद्धे)
 (च) २. कृत्ति for (कृत्ति) ३. यिवस्थिति for (वस्थिति)
९. (घ) १. विमर्ददलनाडिका (ग) (क) for (विमर्दाद्धनाडिका)
 २. ३. पातेष्वृणमसकृतेषु (ग) (क) (च) for (पातेष्वृणमसकृतेषु)
 ४. धनमन्तेः for (धनमन्ते)
 (ग) ५. गुणास्वतिः । (क) गुणास्वगतिः for (गुणाः स्वगतिः)
 (क) ६. रवीन्दु for (रविशशि)
१०. (घ) १. निमीलनं (च) for (निमीलनं)
 (ग) २. तदद्वैक्यम् (क) तदैक्यार्धः for (तयोरैक्यम्)
 (च) ३. माक्षा for (मोक्षा)
 ४. रेक्यम् for (रैक्यम्)
११. (घ) १. हृतं (ग) (क) (च) for (हृतं)
 २. बाहुः for (बाहुः)
 ३. सूर्यशशिपातैः (ग) (क)
 (ग) ४. गुणं for (गुण)
 (क) ५. तत्फलं for (तत्फल)
 ३. सूर्यशशिपातैः for (सूर्यशशिः पातैः)

तात्कालिकविक्षेपः कोटिस्तद्वर्गयुतिपदं कर्णः ।

मानैवद्यार्द्धात्कर्णं विशोध्य तात्कालिको ग्रासः ॥ १२ ॥

असकृत् ग्रासकालोनप्रमाणयुतिदलकृते विशोध्य कृति ।

तत्कालिकविक्षेपस्य शेषमूलकृतं तिथिवत् ॥ १३ ॥

प्रग्रहण स्थित्यार्द्धात् प्राज्यप्रग्रहणतो भवति कालः ।

मौक्षे विशोध्य मोक्षस्थित्यर्द्धात्प्राग् भवेत् मोक्षम् ॥ १४ ॥

स्फुटतिथ्यन्ते मध्यं प्रग्रहणं स्थितिदलोनकेभ्यऽधिके ।

मोक्षो निमीलनोन्मीलने विमर्दार्द्धहीनयुते ॥ १५ ॥

१२. (घ) १. तद्वर्गयुति (ग) तद्वर्ग संयुति for (तद्वर्गयुति)

१३. (घ) १. असकृद्ग्रासकालोन (ग) असकृद्ग्रास कालोन for (असकृद्ग्रासकालोन)

२. तात्कालिक (ग) (च) for (तत्कालिक)

३. शेषमूलं (च) for (शेषमूल)

(ग) ४. कृति for (कृति)

५. तिथिवत् for (तिथिवत्)

(क) १. असकृद्ग्रासकालोन for (असकृद् ग्रासकालोन)

(च) १. असकृद्ग्रासकालोन for (असकृद्ग्रासकालोन)

६. विशोध्य for (विशोध्य)

१४. (घ) १. प्रग्रहणतो (ग) प्राज्यप्रग्रहणतो (क) प्राज्य प्रग्रहणतो for (प्राज्यप्रग्रहणतो)

२. मोक्षात् (ग) (च) for (मोक्षम्)

(ग) ३. भवेत् (क) for (भवेत्)

(क) ४. स्थित्यर्द्धात् for (स्थित्यर्द्धात्)

५. मोक्षं for (मोक्षे)

(च) १. प्राज्य प्रग्रहणतो for (प्राज्यप्रग्रहणतो)

१५. (घ) १. दलोनवधे (क) दलोनकेभ्यऽधिके for (दलोनकेभ्यऽधिके)

(ग) २. प्रग्रहणं for (प्रग्रहणं)

३. स्थितिदलोनकेभ्यऽधिके for (स्थितिदलोनकेभ्यऽधिके)

(च) १. अवग्रहचिह्नलुप्त ४. विमर्दार्द्धं for (विमर्दार्द्धं)

प्राग्^१ पश्चान्त^७विषुवज्यो^२ वंधा^३ त्रिज्ययाप्तचापांशैः ।
 उत्तरयाम्यैः^५ पूर्वा^४ विषुवद्^५ वृत्त्रिमे^६ ग्राह्याः ॥ १६ ॥
 सममंडलविषुवतो ग्राह्या त्रिग्रहाधिकादुदग्याम्यैः ।
 क्रान्त्यंशैरपममंडलपूर्वास्याञ्चन्द्रविक्षेपः ॥ १७ ॥
 एकान्यदिशायुतिवियुतेर्ज्या प्रग्रहणमध्यं मोक्षेषु ।
 बलनं निमीलनोन्मीलनेष्टकालेष्टवो^२ अन्येदिशां ॥ १८ ॥

१६. (घ) १. प्राक् (ग) (क) (च) for (प्राग्)

२. विषुवज्ययो (ग) (क) (च) for (विषुवज्यो)

३. वंधात्रिज्यया (ग) (क) (च) for (बंधात्रिज्यया)

४. पूर्वादिषु for (पूर्वाविषुवद्)

५. वृत्त (ग) वृत् for (वृत्)

६. ग्राह्या (क) for (ग्राह्याः)

(क) ७. पश्चात् विषुवज्ययो for (पश्चान्तविषुवज्यो)

८. याम्यै for (याम्यैः)

९. त्रिमे for (त्रिमे)

१७. (घ) १. सममंडलविषुवतो (ग) for (सममंडलविषुवतो)

२. त्रिग्रहाधिका (ग) for (त्रिग्रहाधिका)

३. पूर्वास्याञ्चन्द्र (ग) (क) (च) for (पूर्वास्याञ्चन्द्र)

(क) १. सममंडलविषुवतो for (सममंडलविषुवतो)

१८. (घ) १. न मीलानान् for (निमीलनोन्)

२. कालेष्टवोऽन्यदिशाम् (ग) (च) for (कालेष्टवोऽन्येदिशां)

(ग) ३. एकान्यदिशां (च) for (एकान्यदिशा)

४. विमलं for (बलनं)

(क) अवराम्यदिशां ज्यातिहि कुतज्यप्रग्रहणमध्यमोक्षेषु ।

बलनं निमीलनोन्मीलनानष्टकालेष्टवोऽन्यदिशाम् ॥ १८ ॥

(च) २. कालेष्टवोऽन्यदिशां for (कालेष्टवोऽन्येदिशां)

आद्यन्त्ययोः सधूम्रः कृष्णः खण्डग्रहेऽर्द्धतोम्यधिके ग्रासः ।
 सकृन् (ष्ण) तान्नः सर्वग्रहणे शशिकपीलवर्णः ॥ १६ ॥
 मानविमर्दस्थितिदलवलनेष्ट ग्रास समकलाद्येषु ।
 चन्द्रग्रहणाध्याय विंशतिरार्याश्चतुर्थीयां ॥ २० ॥
 इति ब्रह्मगुप्ते चतुर्थोऽध्यायः

१६. (घ) १. आद्यन्त्ययोः (ग) (क) for (आद्यन्त्ययोः)

२. षण्डग्रहे (ग) for (खण्डग्रहे)

३. ऽर्द्धतोम्यधिके for (ऽर्द्धतोम्यधिके)

४. ग्रासः (दूसरी पंक्ति का आरम्भ) (ग) (क)

५. शशी (ग) (क) (च) for (शशि)

६. कपिलां (ग) कपिलवर्णः (क) कपिलः for (कपिलवर्णः)

७. वर्णः (यह शब्द नहीं है) (क) 'वर्ण' पद लुप्त

(ग) ८. सुधूम्र for (सधूम्रः)

(च) ३. ऽर्द्धतोम्यधिके for (र्द्धतोम्यधिके) ६. कपिल for (कपील)

२०. (घ) १. दलवलनेष्ट for (दलवलनेष्ट)

२. चन्द्रग्रहणाध्यायो (ग) (क) for (चन्द्रग्रहणाध्याय)

३. चतुर्थीयम् । (ग) (क) for (चतुर्थीयां)

५. 'इति' से 'अध्यायः' तक अंकित नहीं । केवल अध्याय समाप्ति सूचक "छः" अंकित है ;

(च) २. चन्द्रग्रहणाध्याया for (चन्द्रग्रहणाध्याय) ३. चतुर्थीयं for (चतुर्थीयां)

५. 'इति' से 'अध्यायः' तक लुप्त हैं । अध्याय समाप्ति सूचक कोई और चिह्न भी विद्यमान नहीं ।

दृग्गणितैवयं न भवति यस्मात्पंचज्यया रविग्रहरो ।
यस्माद्यथा तदैवयं तथा प्रवक्ष्यामि तिथ्यन्ते ॥ १ ॥
वित्रिभलग्नसमेऽर्केन लम्बनं तदधिकोनके भवति ।
तत्संक्रान्ति ज्योदक् यदाक्षजीवा समा न तदा ॥ २ ॥
अवनतिरतो न्यथा भवति संभवेत्तदुदयैर्विलग्नसमं कृत्वा ।
तदुदितघटिकातः छंकुस्तच्चरप्राणैः ॥ ३ ॥
त्रिज्याकृते चतुर्गुणशंकुहताया फलेन भक्तायाः ।
तात्कालिकार्कराशित्रयो न लग्नान्तरज्याया ॥ ४ ॥

१. (घ) १. दृग्गणितैवयं (च) for (दृग्गणितैवयं)
(ग) ३. तस्माद्यथा for (यस्माद्यथा)
(क) २. 'न' पद लुप्त है ।
३. तस्माद्यथा for (यस्माद्यथा)
२. (घ) १. वित्रिभलग्नसमे for (वित्रिभलग्नसमे)
२. द्योदक् (ग) ज्योदक् (क) ज्यादक् for (ज्योदक्)
(ग) ३. तत्संक्रान्ति (क) तन् संक्रान्ति for (तत्संक्रान्ति)
(च) ४. कर्केन for (ऽर्केन) ३ तत्संक्रान्तिस्थोदक् for (तत्संक्रान्तिज्योदक्)
३. (घ) १. स भवेत्तदुदयै (ग) संभवेत्तदुदयै (क) संभवेत्तदुदयै for (संभवेत्तदुदयै)
२. विलग्न समं for (विलग्नसमं)
३. घटिकास्तछंकुस् (ग) घटिकास्त छंकुं (क) घटिकास्तछंकुस् for (घटिकातः
छंकुस्)
(क) ५. 'कृत्वा' यह पद पूर्वार्ध का अन्तिम न होकर उत्तरार्ध का आरम्भिक है (च)
४. (घ) १. कृतेचतुर्गुण (ग) कृतेचतुर्गुण १०६२२५०० for (कृते चतुर्गुण)
२. हताया (ग) हतायाः (च) हताया for (हताया)
३. राशित्रं for (राशित्र)
४. लग्नान्तरज्यायाः (च) for (लग्नान्तरज्यायाः)
(क) १. कृतेः चतुर्गुण for (कृते चतुर्गुण)
(च) १. कृतेचतुर्गुण for (कृतेचतुर्गुण)

लम्बनघटिकालगनात् तात्कालिकात्त्रिराशूनात् ।
 ऋणां (ऋणां) अधिके ऽर्के हीने धनमसकृत्पंच दृश्यन्ते ॥ ५ ॥
 कर्णगुणाद् व्यासाद्धादिसुवेद ४८ विभाजिता फलविभक्ता ।
 लम्बननाड्यो भास्करवित्रिभलग्नान्तरं वा ॥ ६ ॥
 रविशशिपातगतिकला लम्बनघटिका गुणषष्ठ्या ।
 यदि लम्बनमृणमूना धनमधिकाः स्वफललिप्ताभिः ॥ ७ ॥
 अक्षज्याया वित्रिभलग्नात्स्वक्रान्तिरुत्तरार्कस्य ।
 इन्दोर्वा यद्यधिका न नतिः सौम्या अन्यथा याम्या ॥ ८ ॥

५. (घ) १. लब्धं लंबन (ग) लब्धं लंबन् (च) for (लम्बन)
 २. ऋणमधिके (ग) ऋणमधिकेर्क् हीने (क) ऋणमधिकेर्क् हीने for (ऋणां अधिकेर्क् हीने)
 ३. ससकृत्पंच (क) मसकृत्यं च for (मसकृत्पंच)
 ४. दृश्यते (क) दृश्यन्ते (च) दृश्यंते for (दृश्यंते)
 (क) १. लब्धं लंबन for (लम्बन)
 (च) ५. राशनात् for (राशूनात्) १ ऋणमधिकेर्क् for ऋणां अधिकेर्क्)
६. (घ) १. विभाजितात्फलविभक्ता (ग) विभाजितात्फलविभक्ता (क) (च) for (विभाजिता फलविभक्ता)
 २. लंबतन्याड्यो for (लम्बननाड्यो)
 ३. वित्रिभलग्नान्तर (ग) वित्रिभलग्नान्तर (क) वित्रिभलग्नान्तर for वित्रिभलग्नान्तरं)
 ४. घावा (ग) ज्यावा (क) ज्यावा for (वा)
 (च) ४. लग्नान्तरद्वावा for (लग्नान्तरं वां)
७. (घ) १. गुणाद् हता-गुणा हता (ग) (क) गुणाहता षष्ठ्या for (गुणषष्ठ्या)
 (ग) २. शशिपातागति for (शशिपातगति)
 ३. स्वफललिप्ताभिः for (स्वफललिप्ताभिः)
 (च) १. गुणा हताषष्ठ्या for (गुणषष्ठ्या)
८. (घ) १. अक्षज्याया (ग) अक्षज्याया for (अक्षज्याया)
 २. अवनतिः (ग) (क) अवनतिः for (ननतिः)
 (क) ४. स्वाक्रान्ति for (स्वक्रान्ति)
 (च) ३. वनतिः for (ननतिः)
 ५. अवग्रहचिह्नं लुप्त

वित्रिभलग्नादुत्तरदक्षिण^१विक्षेपहीनसंयुक्तम् ।
 शङ्कुधनु^२रुत्तरायामधिकोनं दाक्षणावनतौ ॥ ९ ॥
 तज्ज्येदु (तज्ज्येदु) शङ्कुराद्यः सविनुः दृक्षेप^१मंडले युक्ते ।
 अपमण्डलेन भानोश्चन्द्रस्य विमण्डलेन युते ॥ १० ॥
 त्रिज्या वर्गावुनौ^१ स्वशङ्कुवर्गेण तत्पदे दृग्ज्ये ।
 रविशशिमध्यगतिगुणो तिथिगुणितव्यासदलभक्ते ॥ ११ ॥
 ४६०५० स्वच्छायागुणिते वा मध्यगति^१तिथिगुणस्वकर्णहृते ।
 फलयोदिक् याम्येतरमवनतिरैक्यं दिगन्यत्वे ॥ १२ ॥
 संयोगान्तरमवनतिशशांकविक्षेपयोः सामान्यदिशोः ।
 स्फुटविक्षेपः शशिवत्^३ स्थित्यर्द्धं^४ विमर्ददलनाड्यः ॥ १३ ॥
 प्राग्वल्लम्बनमसकृत्तिथ्यांतात् स्थितिदलेन हीनयुतात् ।
 अधिकोनं तन्मध्या^२ ऋणयोर्लूनाधिकं धनयोः ॥ १४ ॥

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९. (घ) १. दक्षिण for (दक्षिण)
 २. दक्षिणावनतो (ग) (क) दक्षिणावनतौ for (दाक्षणावनतौ)
 (च) १. दक्षिण for (दक्षिण) २ दक्षिणावनतो for (दाक्षणावनतो)
 १०. (घ) १. दृक् (क) दृक्षेप for (दृक्षेप)
 (च) १. दृक्षेप for (दृक्षेप)
 ११. (घ) १. वर्गावुनौ (ग) वर्गानूनौ (क) वर्गावुनौ for (च) वर्गावुनौ (वर्गावुनौ)
 १२. (घ) १. गती (ग) (क) for (गति)
 २. साम्येतर (ग) साम्येतर (क) साम्येज्तर for (याम्येतर)
 (ग) ३. यह संख्या इस प्रति में अंकित नहीं है ।
 ४. स्वच्छाया (क) तच्छाया for (स्वच्छाया)
 १३. (घ) १. सामान्यदिशोः (ग) (क) सामान्यदिशोः (च) for (सामान्यदिशोः)
 २. स्फुटविक्षेपः for (स्फुट विक्षेपः)
 ३. शशिन for (शशिवत्)
 (ग) ४. स्थित्यर्द्धं (क) for (स्थित्यर्द्धं)
 (च) ३. शशिव for (शशिवत्)
 ५. विमर्द् for (विमर्दं)
 १४. (घ) १. असकृत्तिथ्यांतात् (ग) (च) for (असकृत्तिथ्यांतात्)
 २. मध्याह्णयो (ग) (क) मध्याह्णयो (च) for (मध्याह्णयो)

यद्यधिकं स्थित्यद्वं तदन्तरेणान्यथोनमृणमेकम् ।
 अन्यद्वनं तदेक्येनाधिकमेवं विमर्दाद्वः ॥ १५ ॥
 स्फुटतिथ्यंताल्लम्बनमसकृतस्थित्यर्धहीनयुक्ताद्वा ।
 तत्स्फुटविक्षेपकृतिस्थित्यद्वोनयुततिथ्यन्ते ॥ १६ ॥
 तत्स्पष्टतिथिछेदांतरे स्फुटे तिथिदले विहीनयुतात् ।
 स्वविमर्दाद्वेनाऽसकृदेवं स्पष्टो विमर्दाद्वः ॥ १७ ॥
 शशिवद्वाहुः स्फुटविक्षेपकृतं स्थितिदलेन संगुणिता ।
 स्पष्टः स्थित्यर्धहतो भवति भुजः पूर्ववच्छेषम् ॥ १८ ॥

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१५. (घ) तदेक्येनाधिकमेवं (ग) (च) for (तदेक्येनाधिकमेवं)
 (क) २. विमर्दाद्वे (च) for (विमर्दाद्वः)
१६. (घ) १. कृत (ग) कृतः (च) कृत for (कृति)
 (ग) २. ताल्लंबन for (ताल्लंबन)
 ३. मसकृतस्थित्यद्वं for (मसकृतस्थित्यर्धं)
 (क) यहाँ पूरा श्लोक अंकित नहीं । लिपिकार की भूल से । केवल अंकित है —
 “स्फुटे तस्य ताल्ल तत युत तिथ्यन्ते” ॥ १६ ॥
 (च) ४. तिथ्यांता for (तिथ्यंता)
१७. (घ) १. स्थिति (ग) (क) (च) for (तिथि)
 २. स्पष्टे (ग) (क) (च) for (स्पष्टो)
 (ग) ३. तत्स्फुट for (तत्स्पष्ट)
 ४. विमर्दाद्वं for (विमर्दाद्वे)
 (च) ५. विमर्दाद्वेनाऽसकृदेवं for (विमर्दाद्वेनाऽसकृदेवं)
१८. (घ) १. कृतस्थितिदलेन for (कृतस्थितिदलेन) (ग) कृतः (क) कृतः for (कृतं)
 २. हृतो (ग) (क) (च) for (हतो)
 (ग) ३. संगुणितः (च) for (संगुणिता)
 ४. पूर्ववच्छेषम् (क) पूर्ववत् शेषम् ॥ १८ ॥ for (पूर्ववच्छेषम्)
 (क) ५. विसर्गलुप्त
 ६. विसर्गलुप्त
 (च) १. कृतस्थिति for (कृतस्थिति)
 ४. पूर्ववच्छेषम् for (पूर्ववच्छेषम्)

प्रासात्कालः^३ प्राग्बत्स्पष्टस्थितिदलगुणो^५ सकृद्भूतः^४ ।
 स्फुटविक्षेपऋतस्थितिदलेन^१ शोध्यः^५ स्थितिदलात्स्वात् ॥ १९ ॥
 वलनादिशशिवदन्यत्^२ ग्रहणं^१ तैक्ष्णाद्रैवरनादेश्यम् ।
 द्वादशभागाहूनं^३ स्वच्छत्वात्षोडशादिदे^३ ॥ २० ॥
 न स्फुटमार्यभटादिष्टकग्रहणं^१ यतस्ततः^२ स्पष्टम् ।
 शंकुज्यया कृतं^१ लघु लघुतरमेवं^२ रविग्रहणम् ॥ २१ ॥
 लग्नात्त्रिराशिहीनादपक्रमक्षांशयुतिविशेषोनात् ।
 भतृतया^४ तज्जया^३ भक्ता^३ त्रिज्याद्वै^५ कृतिः^५ ३६७३२२५ फलेन^५ हुता ॥ २२ ॥

१९. (घ) १. विक्षेपकृत (ग) विक्षेपकृतः for (विक्षेपऋत)
 (ग) २. प्रासात्कालः (क) प्रासीत्कालः for (प्रासात्कालः)
 ३. शशिवत् (क) स्पर्शवन् for (प्राग्वत्)
 (क) ४. ऽसकृद्भूतः for (सकृद्भूतः)
 ५. कृत (च) for (ऋत)
 ६. शोध्यः for (शोध्यः)
 ७. स्यात् for (स्वात्)
२०. (घ) १. तैक्ष्ण्याद्रैवरनादेश्यम् (ग) (क) (च) for (तैक्ष्णाद्रैवरनादेश्यम्)
 (ग) २. वदन्यग्रहणम् (क) वदन्यद्ग्रहणम् for (वदन्यत् ग्रहणम्)
 ३. दिदोः (क) for (दिदे)
२१. (घ) १. भटादिष्वर्कं (ग) for (भटादिष्टकं)
 (ग) २. तत्स्पष्टम् (क) ततः स्पष्टम् for (ततः स्पष्टम्)
 (क) ३. रवेर्ग्रहणम् for (रविग्रहणम्)
 (च) १. भटादिष्वर्कग्रहणं for (भटादिष्वर्कग्रहणं)
२२. (घ) १. हीनदप for (हीनादप)
 २. क्रमाक्षांश (ग) (क) (च) for (क्रमक्षांश)
 ३. तज्या for (तज्जया) (ग) ज्याछेदस्त्रिज्या (क) ज्याछेदस्त्रिज्या for (भतृतया तज्जया)
 ४. त्रिज्यार्धकृतिः (ग) ऽर्धकृते २६७३२२५ (क) कृतेः for (त्रिज्यार्धं कृतिः)
 ५. हुता (क) for (हुता)
 (ग) ६. भन्नीतया (क) for (भतृतया)
 (च) ६. भन्नीतया for (भतृतया) ३ तज्या for (तज्जया)
 ४. त्रिज्यार्धकृतिः for (त्रिज्यार्धकृतिः)

त्रिभिः लग्नार्कांतरजीवा^३ धटिकादिलम्बनं लब्धम् ।

वित्रिभलग्नपक्रमविक्षेपाक्षांशयुतिवियुति^४ (ते) ॥ २३ ॥

जीवा शशांकभास्करमध्यमभुक्तांतरेण संगुणिता ।

पंचदश-भिर्गुणितं या विभाजिता त्रिज्यया वनति ॥ २४ ॥

४६०५० पूर्ववदन्यस्पष्टं^१ ब्रह्मोक्तस्पष्टसूर्यशशिपातैः ।

नार्यभटादिभिरुक्तं^२ यतो स्फुटास्ते ततो स्पष्टम् ॥ २५ ॥

२३. (घ) १. भित् लग्नार्कांतर (ग) वित्रिभ लग्नार्कांतरे for (त्रिभिः लग्नार्कांतर)

२. वियुते (ग) (च) for (वियुति (ते))

(ग) ३. जीवाद्य for (जीवाघ)

४. विक्षेपाक्षांश for (विक्षेपाक्षांश)

(क) यहाँ श्लोक की प्रथम पंक्ति लिपिकार लिखना भूल गया । दूसरी है—
“वित्त्रिभलग्नपक्रमविक्षे पक्षांशयुतिवियुतेः ॥ २३ ॥”

(च) १. वित्रिभलग्नार्कांतर for (त्रिभिः लग्नार्कांतर)

२४. (घ) १. मध्यमभुक्तयंतरेण (ग) (क) (च) for (मध्यभुक्तांतरेण)

२. गुणितं (ग) गुणितया (क) for (गुणितं)

(ग) ३. संगुणिता for (संगुणिता)

४. वनतिः (क) for (वनति)

२५. (घ) १. पूर्ववदन्यस्पष्टं (क) (च) for (पूर्ववदन्यस्पष्टं)

२. यतो (ग) यतोऽस्फुटा (क) यतोऽस्फुटस्ते for (यतो स्फुटास्ते)

(ग) ३. ब्रह्मोक्तं for (ब्रह्मोक्त)

४. स्तैततोऽस्पष्टम् (क) स्तैततोऽस्पष्टम् for (स्तैततो स्पष्टम्)

(क) ५. रुक्ते for (रुक्ते)

(च) २. यतो for (यतो)

६. वि०—यहाँ चिह्न लगाकर ऊपर के रिक्तोपान्त पर निम्नलिखित श्लोक—
किसी अन्य हाथ से लिखा हुआ विद्यमान है—

“अंगुलमात्र विरते रक्तः शशिमंडले भवेत्कर्णः ।

भानोस्तु पुन कृदमो वर्णं सर्वत्र निर्दिष्टः ॥”

इष्टप्रासविमर्दस्थित्यद्वा^१ वनति लम्बा^२ नाद्येषु ।

आर्या षड्विंशत्यर्क^३ग्रहण^४पञ्चमोऽध्यायः ॥ २६ ॥

इति ब्रह्मगुप्ते पञ्चमोऽध्यायः ॥

२६. (घ) २. लंबनाद्येषु (ग) for (लम्बानाद्येषु)

२. षड्विंशत्याऽर्कं (ग) (च) for (षड्विंशत्यर्कं)

३. ग्रहणं (ग) for (ग्रहण)

(ग) ४. 'इति' से 'अध्यायः' तक इस प्रति में लुप्त । केवल समाप्ति सूचक छः, छः, छः, अंकित है

यह श्लोक इस प्रति में नहीं है ।

(च) १. लंबनाद्यु for (लंबनाद्येषु)

३. 'इति' से 'अध्यायः' तक लुप्त है ।

ग्रहाभास्करांतरैः प्राक् पश्चादकं^३ग्रहान्तरैर्यस्मात् ।
 स्वांशै^४दृश्या दृश्यास्तस्माद्वक्ष्ये^५ तदानयनम् ॥ १ ॥
 प्रागूनभुक्तिरूनो दृश्ये^३दृश्यो रविरधिकभुक्तिः ।
 पश्चादृश्योऽधिकगतिरधिको गृहो^५ऽल्पगतिः ॥ २ ॥
 विक्षेपसत्रिराशिक्रान्तिवधो व्यासदलहृतो^३ लिप्ताः ।
 शोध्यास्तयोः समदृशोर्यदन्यदिशो ग्रहे^५क्षेपाः ५ ॥ ३ ॥

१. (घ) १. ग्रहाभास्करांतरैः (ग) ग्रहाभास्करांतरैः for (ग्रहाभास्करांतरैः)

(ग) २. वक्षे for (वक्ष्ये)

(क) यह श्लोक उपलब्ध नहीं है ।

(च) १. ग्रहाभास्करांतरैः for (ग्रहाभास्करांतरैः) ३ प्राक्पश्चादकं^३ग्रहांतरै^३ for (प्राक् पश्चादकं^३ग्रहांतरै^३)

४. स्वांशै^४ for (स्वांशै) ५. दृश्या for (दृश्या)

२. (घ) १. रविरधिकभुक्तिः (च) for (रविरधिकभुक्तिः)

२. गति (च) for (गतिः)

(ग) ३. दृश्योदृश्यो for (दृश्येदृश्यो)

४. पश्चादृश्योरधिक for (पश्चादृश्योऽधिक)

(क) यह श्लोक उपलब्ध नहीं है ।

(च) ५. दृश्यो for (दृश्यो)

३. (घ) १. र्यदन्यदिशो (ग) (च) for (र्यदन्यदिशो)

२. ग्रहे (ग) for (ग्रहे)

(ग) ३. हृतो for (हृतो)

४. समदृशो (च) for (समदृशो)

(क) यह श्लोक उपलब्ध नहीं है ।

(च) ५. क्षेप्याः for (क्षेपाः)

विषुवच्छाया^१ गुणिताद्विक्षेपा^४ द्वादशोद्धृता^५ सौम्यात्^२ ।
 फलमृणधनं^३ धनर्णं^६ याम्यादुदयास्तमन्यलग्ने ॥ ४ ॥
 प्रागूनमाद्यमधिकं^७ पश्चात्लग्नाद्ग्रहोदयोस्तमयषड्भयुतम् ।
 अन्यदुदयैः^८ घटिकाः^९ कृत्वा^{१०} नमधिकं^{११} संमम् ॥ ५ ॥

४. (घ) १. विषुवच्छाया (ग) (च) for (विषुवच्छाया)
 २. सौम्यात् (ग) त्सौम्यात् (क) for (सौम्यात्)
 ३. उदयास्तमन्यलग्ने (ग) उदयास्तमन्यलग्ने for (उदयास्तमन्यलग्ने)
 (क) ०. विक्षेपात् । तद्वादशो for (विक्षेपा द्वादशो)
 ५. हृतात् for (द्धृता)
 ६. धनर्णं for (धनर्ण)
 ३. उदयास्तमन्यलग्नौ for (उदयास्तमन्यलग्ने)
 (च) २. सौम्यात् for (सौम्यात्)
 ३. याम्यादुदयास्तमन्यलग्ने for (याम्यादुदयास्तमन्यलग्ने)
 ५. (घ) १. उदयैर्घटिकाः (क) उदयैर्घटिकाः for (उदयैः घटिकाः)
 २. कृत्वोनमधिक (ग) (क) कृत्वोनमधिक for (कृत्वानमधिकं समं)
 (घ) ३. प्रागूना for (प्रागून)
 ४. लग्नात्पश्चाद्ग्रहोदयोस्तमयम् for (पश्चात्लग्नाद्ग्रहोदयोस्तमयः)
 ५. षट्कयुतमन्यदुदयैर्घटिकाः (वि० दूसरी पंक्ति का आरम्भ) for (षड्भ-
 युतम्—द्वि० पं०—अन्यदुदयैर्घटिकाः)
 (क) ४. पश्चात् लग्नात् ग्रहोदयोस्तमयः for (पश्चात्लग्नाद्ग्रहोदयोस्तमयः)
 ५. 'षड्भसंयुतं' for (षड्भयुतम्) दूसरी पंक्ति का आरम्भ
 (च) ५. षड्भयुतं for (षड्भयुतम्)
 १. अन्यदुदयैर्घटिकाः for (अन्यदुदयैः घटिकाः)
 २. कृत्वोनमधिकसमं for (कृत्वा नमधिकं समं)

द्वादशभिः शितांशुसितजीवजशनिभूमिजा नवभिः ।
 द्युत्तरवृद्धैरंतरधटिका षड्गुणिता कलांशैः ॥ ६ ॥
 १२।११।१५।१७ दृश्यादृश्याद्युतिवद्ग्रहार्कं भुत्तचंतरैक्यलब्धदिनैः ।
 अनाधिकलिप्ताभ्यः प्राग्वत् तात्कालिकैरसकृत ॥ ७ ॥
 प्रतिदिनमुदयास्तमयावसकृत् तात्कालिकं ग्रहं विलग्नैः ।
 सूर्यास्तमयोदयिकैः शीतांशौ पौर्णिमास्यन्ते ॥ ८ ॥

६. (घ) १. शीतांशुः (क) (ग) शीतांशुः for (शीतांशु)
 ४. भूमिजातवभिः for (भूमिजानवभिः)
 ३. द्युत्तरवृद्धे (ग) द्युत्तरवृद्धि (क) द्युत्तरवृद्धै for (द्युत्तरवृद्धै)
 ४. कलांशैः (ग) (क) for (कलांशैः)
 ६. निभूमिजा नवभिः । १२।११।१५।१७॥ for (शनिभूमिजा नवभिः)
 (क) ७. षड्गुणित for (षड्गुणिता)
 (च) १. शीतांशु for (शीतांशु) ३ द्युत्तरवृद्धैरंतर for (द्युत्तरवृद्धैरंतर)
 ४. कलांशैः for (कलांशैः)
७. (घ) १. रसकृतः (ग) रसकृत् (क) रसकृत् for (रसकृत)
 (ग) २. यह संख्याएं पूर्वश्लोक के पूर्वाद्ध के पश्चात् अंकित हैं ।
 ३. दृश्याग्रहयुति (क) दृश्यादृश्यायुति for (दृश्यादृश्यायुति)
 (क) ४. ग्रहार्क for (ग्रहार्क)
 ५. ६. भवति for (लब्धदिनैः)
 ७. नैकेनाधिक for (अनाधिक)
 ८. लिप्ताभ्यां for (लिप्ताभ्यः)
 (च) ४. ग्रहार्क for (ग्रहार्क) ७ अनाधिक for (अनाधिक)
 १. रसकृत् for (रसकृत)
८. (च) १. तालिक for (तात्कालिक)
 २. शीतांशौ (ग) शीतांशोः (क) for (शीतांशौ)
 ३. पौर्णिमास्यां च (ग) (क) पूर्णिमास्या च (पौर्णिमास्यन्ते)
 (ग) ४. वसकृत् (क) च सकृत् for (वसकृत्)
 ५. दयकैः (क) दयकैः for (दयिकैः)
 (क) ६. ग्रहविलग्नैः for (ग्रहविलग्नैः)
 ४. वसकृत्तात्कालिक for (वसकृत् तात्कालिक)
 ३. पौर्णिमास्यांत for (पौर्णिमास्यन्ते)

उदयास्तमयावदिदोः कलांशैरकसंमिते कार्यम् ।
हीनत्वं त्वधिकत्वंतरे योग काल स्यात् ॥ ९ ॥
उदयास्तविधौ विवद्बुध्य शीघ्रादाप्तफल युतो न ज्ञः ।
अस्मद्गुरु विहीन समद्ग्र...भागेन ॥ १० ॥
मानाऽल्पत्वात्पश्चादुदयोस्तमयः सितस्य दशभिः प्राक् ।
पश्चान्मानं हत्वा दष्टमयोस्ताभिरुदयः प्राक् ॥ ११ ॥

९. (क) यह श्लोक मूल पाठ में नहीं है । (ग)

(क) यह श्लोक उपलब्ध नहीं है ।

(च) वि० यहाँ यह श्लोक निम्न उपान्त पर अन्यहस्तलेख में दिया गया है—

१. उदयस्तमयवदिदोः for (उदयास्तमयावदिदोः)

१०. (घ) यह श्लोक मूल पाठ में नहीं है । (ग) (क)

(च) वि० यह श्लोक २५b पृष्ठ पर निम्नोपात पर अग्यपस्त से दिया हुआ है !

१. नोज्ञः for (नज्ञः) २ विहिनः for (विहीन)

३. ससम for (समद्ग्र)

११. (घ) इसका संख्याक्रम ९ है (ग)

१. माता for (माना)

२. मानमहत्वा (क) (क) for (मानं हत्वा)

३. दस्तमयो (ग) (क) for (दष्टमयो)

४. ष्ठाभि (ग) (क) for (स्ताभि)

(ग) ५. दशभिः (क) (च) for (दशभि)

६. रुदय (क) for (रुदयः प्राक्)

(क) ७. दुदयो for (पश्चादुदयो)

८. ऋतमयो for (स्तमयः)

(च) २. मानमहत्वादस्तमयो for (मानं हत्वादष्टमयो)

४. ष्ठाभिरुदयः for (स्ताभिरुदयः)

९. क्रमसंख्या '९' है !

ज्ञस्यैवं^१ मनुसूर्ये^२ पठितैः^३ कुजजीवपुत्राणाम् ।

उदय^४ प्राग्^५ ऽस्तमयो मानसमत्त्वाद्भवति पश्चात् ॥ १२ ॥

आर्यभटः^६ क्षेत्रांशैर्दृश्यान्^७ दुक्तवास्तदसत् ।

दृग्गणितैक्यं^८ विसंवाहा^९ दृग्गणितैक्यं^{१०} स्वकालांशैः^{११} ॥ १३ ॥

१२. (घ) इसका संख्याक्रम १० है (ग)

१. ज्ञास्यैवं (ग) ज्ञस्यैव (क) ज्ञास्यवं for (ज्ञस्यैवं)

२. पठितै (क) पठितै for (पठितैः)

३. जीवसूर्यपुत्राणाम् (वा) (क) जीवसूर्यपुत्राणां for (जीवपुत्राणाम्)

४. उदयः (ग) (च) for (उदय)

५. प्रागस्तमयो (ग) प्रागस्तमयौ (क) प्रागस्तमयो for (प्राग्ऽस्तमयो)

(ग) ६. माह्नमहत्त्वाद्भवति पश्चात् for (मानसमत्त्वाद्भवति पश्चात्)

(क) ७. ॥ १० ॥ (च) for (॥ १२ ॥)

(च) २. पठितै for (पठितैः) ३ + सूर्य +

५. प्रागस्तमयो for (प्राग् ऽस्तमयो)

१३. (घ) इसकी क्रमसंख्या ११ है (ग)

१. दुक्तवास्तदसत् (ग) (च) for (दुक्तवास्तदसत्)

२. स्वकालांशैः । ११ । (ग) स्वकाल्पांशैः for (स्वकालांशैः)

३. रेखांकित पाठ मूल में नहीं है ।

(ग) ४. दृश्याद्युक्त for (दृश्यान्^७ युक्त)

५. दृग्गणितं विसंवादा (क) दृग्गणितं विसंविवादात् for (दृग्गणितैक्यं विसंवाहा)

(क) ६. आर्यभट्ट for (आर्यभटः)

७. अदुक्तवान् तदसत् for (अदुक्तवास्तदसत्)

८. सूपवित्तकालांशैर्दृग्गणितैक्यं भवति ॥ ११ ॥ for (विसंवाहा दृग्गणितैक्यं स्वकालांशैः ॥ १३ ॥)

(च) २. स्वकालांशैः for (स्वकालांशैः)

८. दृग्गणितैक्यं for (दृग्गणितैक्यं)

दृग्लग्न^१ दृष्टिभाग^४ ग्रहोदयास्तमयनाडिकाद्यैषु ।
मयाध्यायः^२ चतुर्दशभिरार्याभिः^३ ॥ १४ ॥
इति^५ ब्रह्मगुप्ते षष्ठोऽध्यायः ।

१४. (घ) इसकी क्रमसंख्या १२ है (ग)

१. दृग्लग्न दृष्टिभाग (ग) दृग्लग्नदृष्टिभाग for (दृग्लग्न दृष्टिभाग)
२. उदयास्तमयाध्यायः षष्ठो (ग) (क) उदयास्तमयो for (मयाध्यायः)
३. द्वादशभिरार्याभिः । द्वादशभिरार्याभिः । for (चतुर्दशभिरार्याभिः)
५. 'इति' से 'अध्यायः' तक मूल प्रति में नहीं है । केवल समाप्तिसूचक "छः" चिह्न है ।

(क) ६. अध्यायषष्ठो द्वादशाभिरा र्याभिः for (अध्यायः चतुर्दशभि रार्याभिः ॥ १४ ॥)

- (घ) २. उदयास्तमयाध्यायः षष्ठो for (मयाध्यायः)
३. द्वादशभि for (चतुर्दशभि)
४. 'इति' से 'अध्यायः' तक लुप्त है ।

सितवृद्धिं हानिर्वा यदि शापाज्जायते कथं गणितात् ।
 उपरि खेरिन्दुचेदंर्धागर्धं सदा शुक्लां ॥ १ ॥
 रविद्वष्टं सितमर्द्धं कृष्णमदृष्टं यथा तपस्थस्य ।
 कुम्भस्य तथासन्नं खेरर्धस्थस्य चन्द्रस्य ॥ २ ॥

- (घ) १. (ग) शापात् जायते for (शापाज्जायते)
 ५. कथं (ग) 'अनंकित' है for (कथं)
 ३. दर्वागर्धं (ग) for (दंर्धागर्धं)
 ४. शुक्लम् (ग) for (शुक्लां)
- (ग) २. गणितात् for (गणितात्)
- (च) ५. कथं for (कथं)
 ३. चेदंर्धागर्धं for (चेदंर्धागर्धं)
- (क) १. २. गणितात् for (गणितात्)
 ३. दर्वागर्धं for (दंर्धागर्धं)
 ४. शुक्लं for (शुक्लां)
 ६. वृद्धिर्हानि for (वृद्धिहानि)
२. (घ) १. दृष्टं (ग) द्विष्टं for (द्रष्टं)
 ४. रधस्थस्य (ग) for (रर्धस्थस्य)
- (ग) ३. मकृष्णं for (मदृष्टं)
 ५. तस्य for (तस्य)
- (च) १. दृष्टं for (द्रष्टं)
- (क) १. दृष्टं for (द्रष्टं) २. सितमर्द्धं (सितमर्द्धं) ३. दृश्यं for (दृष्टं) ४. रघः for (रर्धं)

सिममुण्णतं यतोर्कं सितासितं शुक्लकृष्णपक्षांते ।
 अर्धागद्धं पश्चाद्गणिता छृंगोन्नतिस्तस्मात् ॥ ३ ॥
 रविचन्द्रपात लग्नैः स्वक्रान्त्युदयास्तलग्नगतशेषाः ।
 घटिकाः स्वचराद्धस्तौ स्वेष्टकालिकैः शीतगो कृत्वा ॥ ४ ॥

३. (घ) १. मुन्नतं (ग) (च) for (मुण्णतं)

२. यतोर्कः (ग) (च) for (यतोर्कं)

६. सुक्ल for (शुक्ल)

३. अर्धागद्धं (ग) (च) for (अर्धागद्धं)

४. यस्माद्गणिता (ग) for (पश्चाद्गणिता)

५. छृंगोन्नतिस्तस्मात् (ग) for (छृंगोन्नतिस्तस्मात्)

(क) १. मुन्नतं for (मुण्णतं) २. यतोर्कः for (यतोर्कं) ३. अर्धागद्धं for (अर्धागद्धं)

४. यस्मान् गणितान् for (पश्चाद्गणिता) ५. शृंगोन्नति तस्मान् for (छृंगोन्नतिस्तस्मात्)

४. (घ) २. लग्नैः (च) for (लग्नैः)

३. स्वचरास्त for (स्वचराद्धस्तौ)

(ग) ४. पाता for (पात)

५. गतः for (गत)

६. घटिका स्वचरास्तं for (घटिकाः स्वचराद्धस्तौ)

७. श्वेष्ट for (स्वेष्ट)

८. शीतगोः (च) for (शीतगो)

(क) १. रवि चन्द्रपातलग्नैः शृङ्गोन्नतिकालिकैः स्वक्रान्ति उदयस्तलग्नगतशेषघटिकाः ।

स्वचरांश्च कृत्वा प्रति घटिका शृङ्गोन्नति गणनीयः ॥

for

(रविचन्द्रपातलग्नैः स्वक्रान्त्युदयास्तलग्नगतशेषाः ।

घटिकाः स्वचराद्धस्तौ स्वेष्टकालिकैः शीतगो कृत्वा ॥४॥)

शशिविक्षेपाक्रमधनुषो योगान्तरं समान्यदिशोः ।
 सज्ज्येद्वयक्रमज्या स्वाहोरात्राद्यतो रविवत् ॥ ५ ॥
 स्वक्रान्तिज्ये त्रिज्यागुणे हते लम्बकेन रविशशिनोः ।
 अग्रे पृथक् स्वशंकुतल तुल्ययुक्ते विदिक् विद्युते ॥ ६ ॥

५. (घ) ६. धनुष्योर्गोतं for (धनुषोयोगांतरं)

३. तज्ज्येद्वयक्रमज्या (ग) तज्ज्येद्वयक्रमज्या for (सज्ज्येद्वयक्रमज्या)

(ग) १. विक्षेपाक्रम for (विक्षेपाक्रम)

७. योगान्तरं for (योगान्तरं)

(च) ६. धनुर्वयोर्गोतं for (धनुषो योगांतरं)

३. तज्ज्येद्वयक्रमज्या for (सज्ज्येद्वयक्रमज्या)

(क) १. विक्षेपराम्यपक्रम for (शशिविक्षेपाक्रम) २. सभोना for (समान्य)

३. तज्ज्ये for (सज्ज्ये) ४. क्रमज्यात् for (क्रमज्या) ५. यातौ for (यतो)

६. (घ) २. हते (च) for (हते)

६. शशिनोः for (शशिनोः) (च)

७. अग्रे for (अग्रे)

(ग) ४. युते for (युक्ते)

५. न्यदिग्वियुते for (विदिक् विद्युते)

(क) १. ज्योतिज्ये for (क्रान्तिज्ये) २. वृते for (हते) ३. लावकेन for (लम्बकेन)

४. युते for (युक्ते) ५. विदिम् for (विदिक्)

पृथगन्तरं संयोगौ भुजो युतोर्काछशी समान्यदिशो ।
 दिग्ज्या वर्गात्स्वात् स्वपृथक्स्थं वर्गं विशोध्य पदे ॥ ७ ॥
 विपुतसहिते रविन्द्वौ रेकान्यकपालसंस्कृतयोराद्य ।
 रविशशिदृक् शंक्वन्तरमन्योऽदृक् दृश्यशंकैक्यम् ॥ ८ ॥

७. (घ) १. पृथगन्तरं (ग) (च) for (पृथगन्तरं)

३. च्छशी (च) for (छशी)

४. समान्यदिशोः (ग) (च) for (समान्यदिशो)

५. दृग्ज्या (ग) दृक्ज्या वर्गात् for (दिग्ज्यावर्गात्)

७. स्वात्स्वं (ग) स्वात्स्वपृथक् स्थवर्ग for (स्वपृथक्स्थं वर्गं)

(ग) ८. भुजौ for (भुजौ)

६. विशोध्यशेषपदे for (विशोध्यपदे)

(च) २. युतोऽर्का for (युतोर्का) ५. दृग्ज्या for (दिग्ज्या)

७. स्वात्स्वं for (स्वात्स्व) ६. पृथक् स्वर्ग for (पृथक्स्थं वर्गं)

(क) १. पृथगन्तरं for (पृथगन्तरं) २. युतोऽर्कात् for (युतोर्का)

३. छशी for (छशी)

४. सामान्य दिशोः for (समान्यदिशो) ५. दृग्ज्यावर्गात् स्वस्वं for (दिग्ज्या-
 वर्गात्स्वात् स्व) ६. पृथक् स्ववर्ग for (पृथक्स्थं वर्गं)

८. (घ) ६. रविन्द्वौ (ग) (च) for (रविन्द्वौ)

२. संस्थयोराद्यः (ग) (च) for (संस्कृतयोराद्यः)

७. शंक्वन्तरं (ग) शंक्वन्तर for (शंक्वन्तर)

४. दृग् (ग) दृश्यशंकैक्यम् for (दृश्यशंकैक्यम्)

(च) ४. दृग् for (दृक्)

(क) १. सहिते for (सहिते) २. संस्थयोराद्यः for (संस्कृतयोराद्यः)

३. दृक् for (दृक्)

४. दृक् for (दृक्) ५. शंकैक्यम् for (शंकैक्यम्)

आद्यन्तवर्गयोगान्मूलं पूर्वापरात् भुजात् कोटिः ।
 भुजकोटिकृतियुतिपदं तिर्यक्कर्णस्य चन्द्राग्रं ॥ ६ ॥
 एवं तावाद्यावन्यदयोराद्यन्तयो शशिन्यर्कः ।
 रविरर्द्धचक्रयुक्त कल्पो द्वितृतीयोरर्कः ॥ १० ॥
 व्यकन्दुदलभुजाशाः शशिमानगुणाः शितं नवतिभक्ताः ।
 द्विगुणांशो क्रमजीवाद्यावन्नवतिरंशाः ॥ ११ ॥

६. (घ) १. आद्यान्यवर्ग (ग) आद्यान्यवर्ग for (आद्यन्तवर्ग)
 २. पूर्वापरा (ग) for (पूर्वापरात्)
 ३. चन्द्राग्रे (च) for (चन्द्राग्रे)
 (ग) ४. भुजाः for (भुजात्)
 ५. तिर्यक्कर्णस्य (च) for (तिर्यक्कर्णस्य)
 (च) १. आद्यान्त्य for (आद्यन्त) २. पूर्वापरा for (पूर्वापरात्)
 (क) १. आद्याल्प for (आद्यन्त) २. पूर्वापराभुजाकोटि for (पूर्वापरात् भुजात् कोटिः)
१०. (घ) १. तावाद्यावत्पदयो (ग) तावाद्यावत्पदयो for (तावाद्यावन्यदयो)
 ३. शशीव्यर्कः (ग) (च) for (शशिन्यर्कः)
 ५. द्वितृतीययोरर्कः (ग) for (द्वितृतीयोरर्कः)
 (च) १. तावाद्यावत्पदयो for (तावाद्यावन्यदयो)
 ५. द्वित्रितीययोरर्कः for (द्वितृतीयोरर्कः)
 (क) १. तावद्यावत्पदयो for (तावाद्यावन्यदयो) २. राज्यतयो for (राद्यन्तयो)
 ३. शशीज्यवर्क for (शशिन्यर्कः) ४. युक्तः for (युक्त) (ग) युक्तः ६ कलो for (युक्तकल्पो)
 ५. द्वितृतीयोरर्कः for (द्वितृतीयोरर्कः)
११. (घ) १. भुजांशाः (ग) (च) for (भुजाशाः)
 ३. नवतिभक्ता (च) for (नवतिभक्ताः)
 ५. द्विगुणांशोत्क्रमजीवा (च) for (द्विगुणांशो क्रमजीवा)
 ४. तावाद्यावन्नवतिरंशाः (ग) तावाद्यावन्नवतिरंशाः for (द्यावन्नवतिरंशाः)
 (घ) ६. शितं for (शितं)
 (च) ७. व्यकन्दु for (व्यकन्दु) ३ नवतिभक्ता for (नवतिभक्ताः)
 (क) १. भुजांशाः for (भुजाशाः) २. शशिमानगुणाशितं for (शशिमानगुणाःशितं)
 ३. भवति for (नवति) ४. जीवातावद् यावन्नवतिरंशाः for (जीवाद्यावन्नवतिरंशाः)

नवतेरधिकांशानां क्रमज्यया संयुतो क्रमत्रिज्या ।
 चन्द्रप्रमाणगुणिता द्विगुणा व्यासाद्ध भक्तान्यत् ॥ १२ ॥ ६५ । ४०
 प्रथमं शुक्लं रात्रौ दिवसेन्यसंध्योस्तदैक्यार्धम् ।
 वर्णोग्रासवर्दिदावसितस्य सितं श्रवणं गत्या ॥ १३ ॥
 शशिमानपादवर्गो नामाद्ध सितान्तराद्ध भक्तयुतः ।
 परिलेखसूत्रमध्ये शुक्लेद्ध ज्यैव परिलेखः ॥ १४ ॥

१२. (घ) ३. रधिकांशाः नां (ग) रधिकांशानां for (रधिकांशानां)
 २. संयुतोत्क्रम (ग) संयुतोत्क्रमे (च) for (संयुतोत्क्रम)
 ४. द्विगुण for (द्विगुणा)
 (ग) ५. ६५।४० for (६५।४०)
 (च) ३. रधिकांशाः नां for (रधिकांशानां)
 (क) नचते रधिकांशानां for (नवतेरधिकांशानां) २. क्रम for (क्रम)
१३. (घ) २. दिन्य for (दिवसेन्य)
 ३. वर्णोग्रास for (वर्णोग्रास)
 ४. श्रवण (च) for (श्रवणं)
 (ग) ५. कर्णेन चन्द्रबिम्बे शेषस्य ग्रासवर्णः for (वर्णो ज्यासवर्दिदावसितस्य)
 (च) ६. तदैक्यार्धम् for (तदैक्यार्धम्)
 (क) १. शुक्ल (शुक्लं) for (शुक्लं) २. दिवसेन्यत् for (दिवसेन्य)
 ३. वर्णोग्रासवर्दिदावसितस्य for (वर्णोग्रासवर्दिदावसितस्य) ४. श्रवण for (श्रवणं)
१४. (घ) ४. परिलेख द्वे शुक्लेद्ध ज्यैव (ग) परिलेखसूत्रमध्ये शुक्लेद्ध ज्यैव for (परिलेख-
 सूत्रमध्ये शुक्लेद्ध ज्यैव)
 ३. शुक्लेद्ध ज्यैव for (शुक्लेद्ध ज्यैव)
 ५. परिलेखः (च) for (परिलेखः)
 (ग) २. पादवर्गोनामाद्ध for (पादवर्गोनामाद्ध)
 ६. वराद्ध for (तराद्ध)
 ७. भक्तयुतः for (भक्तयुतः)
 (च) ४. सूत्रमध्ये for (सूत्रमध्ये)
 ३. शुक्लेद्ध ज्यैव for (शुक्लेद्ध ज्यैव) ५. परिलेखः for (परिलेखः)
 (क) १. शशिमान for (शशिमान) २. पादवर्गोनामाद्ध for (पादवर्गोनामाद्ध)
 ३. शुक्लेद्ध ज्यैव for (शुक्लेद्ध ज्यैव)

त्रिप्रश्नोत्तया शंकोः पूर्वापरतो निधाय दिग्मध्ये ।
 छायाग्रं छायाग्रंछकुंग् दीर्घसूत्रवशात् ॥ १५ ॥
 कृत्वा विंशद्वितयं दृगुद्धृतं पृथग्मुच्चरतमन्यत् ।
 प्रथमाग्रस्थितदृष्ट्या द्वितीयवंशाग्रं चन्द्रम् ॥ १६ ॥

१५. (घ) ३. छायाग्रा (ग) छायाग्रात् for (छायाग्र)

२. छंक्वग्र (क) शक्वग्र for (छंकुंग्र)

(ग) १. शंकुं for (शंकोः)

४. तधाय for (निधाय)

(च) ५. त्रीप्रश्नोत्तया for (त्रिप्रश्नोत्तया)

२. छंकुग्र for (छंकुंग्र)

(क) १. शंकुं for (शंकोः) २. त्र्यंक्वग्र for (छंकुंग्र)

(ग) श्रवकेन्दुदलभुजांशार्द्धं ज्याकर्णो द्विगुणिता भुजस्य कृति ।

प्रोह्य पदं.....भुजाग्रचंद्रांतरं कोटिः ॥ १६ ॥

यह श्लोक 'ग' में अतिरिक्त पाया गया है ।

१६. (घ) ३. प्रथममुच्चतर for (पृथग्मुच्चरत)

४. वंशाग्रं for (वंशाग्रं)

(ग) १. वंश for (विंशा)

२. दृगुद्धृतम् for (दृगुद्धृतं)

५. द्रिष्ट्या for (दृष्ट्या)

६. चन्द्रे for (चन्द्रम्)

(वि० इसकी क्रमसंख्या १८ है)

(च) ३. प्रथममुच्चरतमन्यत् for (पृथग्मुच्चरतमन्यत्)

(क) १. वंश for (विंशा) (ग) दृगुद्धृतं (ग) for (दृगुद्धृतं) ३. प्रथम-
 मुच्चतरमन्यत् for (पृथग्मुच्चरतमन्यत्)

ग्रहरां ग्रहयोगं वा विस्मयकरणाय दर्शयेद् गणकः ।
 लोकस्य नरपतेर्वा दुष्करमन्यैर्गणितविद्भिः ॥ १७ ॥
 इति बाहुकर्णकोटिस्फुटसितपरिलेखसूत्रकर्णेषु ।
 आर्याष्टादश चन्द्रशृंगोन्नतिरिह सप्तमोऽध्यायः ॥ १८ ॥
 इति श्रीब्रह्मगुप्ते सप्तमोऽध्यायः

(ग) लब्धेवं वानतयोः पूर्वापरयोः खेस...चक्रात् ।

अग्रविकटोः शुक्लं पश्चाच्छुक्ले सिते पूर्वात् ॥ १७ ॥

यह श्लोक 'ग' में अतिरिक्त पाया गया है ।

१७. (घ) २. ग्रहयो योगं for (ग्रहयोगं)

३. गणितविद्भिः (ग) गणितवद्भिः for (गणितविद्भिः)

(ग) इसकी क्रमसंख्या १६ है ।

४. विस्मय for (विस्मय)

(क) १. नरपतेर्दुष्कर for (नरपतेर्वादुष्कर)

१८. (ग) वि०—इसकी क्रमसंख्या २० है ।

३. इतिपादकोटिकर्णः for (इतिबाहुकर्णकोटि)

४. परिलेख for (परिलेख)

२. विंशतिरार्या शृंगोन्नतिरिदोः सप्तमोऽध्यायः for (आर्याष्टादशचन्द्रशृंगोन्न-
 तिरिह सप्तमोऽध्यायः)

(च) ५. अवग्रहचिह्नं लुप्त

६. "इति" से "अध्यायः" तक लुप्त है ।

(क) १. कोटिकर्ण for (कोटि) २. आर्याष्टादशभिः for (आर्याष्टादश)

प्राक्^३चन्द्रल^२ग्नयोरस्तल^४ग्नशशिनो यतोन्तरात्पश्चात् ।
 प्रतिदिनमिन्दुच्छाया यतस्तदानयनमभिधास्ये ॥ १ ॥
 प्रग्रहणकालिकैरिष्टकालिकैर्वर्किल^३ग्नशशिपातैः ।
 कृत्वोदयास्तलग्ने स्वचरप्राणान् शंशाकस्य ॥ २ ॥
 यद्यधिकमुदयलग्नादूनं^४ षड्ग्रहयुतास्तमयलग्नात् ।
 लग्नं तदा शशांको दृश्यः सवितुर्दर्शने छाया ॥ ३ ॥
 लग्नसममुदयलग्नं षड्ग्रहयुतास्त लग्नं समम् ।
 पूर्वपरयोः कृत्वा गतशेषाः स्वोदयैर्घटिका ॥ ४ ॥

१. (घ) १. यतोन्तरात् (ग) यतोन्तरात् (च) for (यतोन्तरात्)
 २. प्रतिदिनछाया for (प्रतिदिनमिन्दुच्छाया)
 (ग) ३. रश्मि for (रस्त)
 ४. ततस्तानयनमभिधास्ये for (यतस्तदानयनमभिधास्ये)
 (च) १. यतोन्तरात् for (यतोन्तरात्)
 (क) यतोन्तरात् for (यतोन्तरात्)
२. (घ) १. शशांकस्य for (शंशाकस्य)
 (ग) २. काकालिकै for (कालिकै)
 (च) ३. वर्किल for (वर्किल)
 (क) १. शशांकस्यात् for (शंशाकस्य)
३. (घ) २. षड्ग्रह (ग) for (षड्ग्रह)
 १. सविदर्शने (ग) सतिदर्शने for (सवितुर्दर्शने)
 (ग) ३. छायाः for (छाया)
 (च) ४. दूनं for (दूनं) २. षड्ग्रह for (षड्ग्रह)
 १. सवितुदर्शने for (सवितुदर्शने)
 (क) १. सति for (सवितु)
४. (घ) ३. षड्ग्रहयुता (ग) (च) for (षड्ग्रहयुता)
 ४. लग्नसमं (ग) (च) for (लग्नसमं)
 (ग) ५. गशेषाः for (गतशेषाः)
 ६. घटिकाः for (घटिका)
 (क) १. लग्न लग्न for (लग्नं) २. युताश्च for (युतास्त)

गतघटिकाः शेषा वा स्वदिनाद्धं समावंदीदुरद्धाद्धं ।

गतशेषनाडिकाभिर्नन्ताभिरथैवार्कवच्छंकुः ॥ ५ ॥

शंकुधनुषोऽधिकस्य स्फुटप्रमाणार्द्धं लिप्तिकाभिर्वा ।

रविशशिमध्यगतिकला तिथ्यंशज्योनिताछेदः ॥ ६ ॥

द्वादशभिर्गुणितायां दृज्या लब्धमंगुलाद्यं यत् ।

तत्प्रग्रहे छाया स्फुटा न्यादावान्यथाऽऽसन्ता ॥ ७ ॥

५. (घ) १. यदीदुमह्लोद्धं (ग) यदीदुरह्लोद्धं for (वंदीदुरद्धाद्धं)

२. नवाभि for (नन्ताभि)

३. रथैवार्कवच्छंकुः (ग) for (रथैवार्कवच्छंकुः)

(च) १. यदीदुरह्लोद्धं for (वंदीदुरद्धाद्धं)

२. रथैवार्क for (रथैवार्क)

(क) १. समावदादुरह्लोद्धं for (समावंदीदुरद्धाद्धं) २. रस्त्र for (रथ)

३. वत् शंकुः for (वच्छंकुः)

६. (घ) १. ज्या (ग) ज्या for (वी)

३. शद्योनिपाछेदः (ग) श ज्योनिवच्छेदः for (शज्योनिताछेदः)

(क) १. र्या for (वी) २. तला for (कला) ३. सज्योनिताछेदः for (शज्योनिता-
छेदः)

७. (घ) १. १२. दृज्याया (ग) दृज्याया for (दृज्या)

३. तत्प्रग्रहणे (ग) सा प्रग्रहणे for (तत्प्रग्रहे)

५. छा for (छाया)

४. स्फुटान्य (च) स्फुटान्य for (स्फुटान्या)

६. यथासन्ता (ग) कन्ययासन्ता for (यथाऽऽसन्ता)

(च) ७+१२+ १. दृज्याया for (दृज्या)

३. तत्प्रग्रहणे for (तत्प्रग्रहे) ८. अवग्रहचिह्नं लुप्त

(क) १. दृज्याया for (दृज्या) २. मंगुलाप्तं for (मंगुलाद्यं)

प्रग्रहणे for (प्रग्रहे) ४. न्यादा (ग) for (न्यादा)

ज्येष्ठा^१पक्रमभागे^५र्मध्यछाया^२र्कवच्छां^४कस्य ।
 शशिव^३मादाता^५मृक्षाणां^४ तु स्वकांत^४ ध्रुवकात् ॥ ८ ॥
 इह^५ नोदृष्टं^५ यत्तद्रविवद्गतशेषनाडिकाद्येषु ।
 आर्याभिर्नवाभिरयं^२ चन्द्रछायाऽष्टमोऽध्यायः ॥ ९ ॥
इति श्री ब्रह्मगुप्ते अष्टमोऽध्यायः ॥

८. (घ) १. स्वेष्ठा (ग) for (ज्येष्ठा)

२. वच्छां^४कस्य for (वच्छां^४कस्य)

३. शशिवद्भौमादीनामृक्षाणां (ग) शशिवद्भौमादीनां नक्षत्राणां च for (शशिवमादातामृक्षाणां)

(ग) ४. स्वकाध्रुवकात् for (स्वकांतध्रुवकात्)

(च) ५. छाया^५र्कं for (छाया^५र्क) ४. स्वकात् for (स्वकांत)

(क) १. स्वेष्ठा for (ज्येष्ठा) ३. शशिवत्भौमादीनां नक्षत्राणां स्वकान् ध्रुवकान् for (शशिवमादाता मृक्षाणां तु स्वकांतध्रुवकात्)

९. (घ) २. नवभि for (नवाभि)

३. चन्द्रछायां ष्टमोऽध्यायः for (चन्द्रछायाऽष्टमोऽध्यायः)

(ग) ४. हनोदृष्टं for (इहनोदृष्टं)

१. यत्तद्रविवत्तच्छेष for (यत्तद्रविवद्गतशेष)

५. आर्यानिनवाभिरयं for (आर्याभिर्नवाभिरयं)

समाप्तिसूचक छः ॥ छः ॥ छः रेखांकित के स्थान में

(च) २. नवाभिरयं for (नवाभिरयं)

३. अग्रग्रह चिन्हलुप्त

६. छाः श्री for ("इति.....अध्यायः")

(क) १. यद्गविवत् for (यत्तद्रविवद्गत) २. नवाभिरयं for (नवाभिरयं)

३. चन्द्रछाया for (चन्द्रछाया)

शून्येशा यमतिथयः षडगाः षट्भिन्दवः स्वगुण चन्द्राः ।

क्रान्तिविक्षेपकालाः कुजबुधगुरुशुक्ररविजानां ॥ १ ॥

११० । १५२ । ७६ । १३६ । १३०

व्यासार्द्धं संयुक्तं त्रिगुणान्त्य फलज्ययान्त्यकरणेन ।

त्रिधनगुणं २७ स्वदशांशैर्गुणायांत्य फलज्ययाभक्तं ॥ २ ॥

स्फुटमानकलाभूमिजबुधसुरगुरुशुक्रसूर्यपुत्राणां ।

नाधःस्वयोर्द्रसितयोरासन्नत्वाद्भवेरसितम् ॥ ३ ॥

१. (घ) ६. मतिथियः (ग) यमातिथियः १५२ for (यमतिथयः)

१. षट्त्रिन्दवः (ग) for (षट्भिन्दवः)

(ग) ७. शून्येशा ११० for (शून्येशा)

८. १३६ खगुणाचन्द्राः for (स्वगुणाचन्द्राः)

२. ३. क्रान्तिविक्षेपकला for (क्रान्तिविक्षेपकालाः)

(च) ६. तिथियः for (तिथयः) १. षट्त्रिन्दवः for (षट्भिन्दवः)

(क) १. षट्त्रिन्दवः for (षट्भिन्दवः) २. क्रान्ते for (क्रान्ति) ३. कला for (कालाः)

४. शुक्रः for (शुक्र) ५. योनाम् for (जानां)

२. (घ) ५. त्रिधन (ग) त्रिधनगुणं for (त्रिधनगुणं)

२. स्वदशांशै for (स्वदशांशै)

३. गुणायांत्य for (गुणायांत्य)

(ग) ६. स्वयांत्यकरणेनम् for (ज्ययान्त्यकरणेनं)

७. त्यहणं दौर्गुणायांत्यफलभक्तम् ॥ २ ॥ for (स्वदशांशैर्गुणायांत्यफलज्या-भक्तम् ॥२॥)

(च) ५. त्रिधन for (त्रिधन) ७. स्वदशांशै for (स्वदशांशै)

३. गुणायांत्य for (गुणायांत्य)

(क) १. कणात् for (कराणं) २. दशांशैः for (दशांशै) ३. गुणायांत्य for (गुणायांत्य)

४. भक्ता for (भक्तं)

३. (घ) २. स्थयो (ग) नाधस्थयोर्ज्ञ for (नाधः स्वयोर्द्रं)

(च) २. स्थयोर्द्रं for (स्वयोर्द्रं)

(क) १. गुरुदैत्येज्य for (सुरगुरुशुक्र) २. स्थयोर्ज्ञ for (स्वयोर्द्रं) ३. रसितम् for (रसितम्)

भुक्त्यन्तरेण^१ भुक्तं^२ ग्रहान्तरं^३ फलदिनैरधिकं^४ भुक्तौ जीवरविजानां ।
 प्रागूनगतौ पश्चाद्भुतिरधिके^५ वक्रिणोर्व्यस्ता ॥ ४ ॥
 एको वक्रिभुक्तचोयुत्योनः^६ प्रागथादधिकः ।
 पश्चात् ग्रहयोरन्तर लिप्तास्तथैवभक्ताः^७ स्वभुक्तिः^८ गुणाः ॥ ५ ॥
 स्वफलमृणं प्राक् पश्चाद्युतौ धनं वक्रिणी ग्रहे व्यस्तम् ।
 समलिप्तौ बुधसितशीघ्रचन्द्रपाते च स्वफलम् ॥ ६ ॥

४. (घ) ६. दिवैरधिकभुक्तौ (ग) दिनैरधिकभुक्तौ for (दिनैरधिकं भुक्तौ)

४. पश्चाद्युति (ग) पश्चाद्युति for (पश्चाद्भुति)

५. व्यस्ता भुक्तिगुणाः (ग) व्यस्ताः for (व्यस्ता)

(ग) १. भक्तं for (भुक्तं)

इस श्लोक की प्रथम पंक्ति का अन्तिम शब्द “जीवरविजानां” इस प्रति में उपलब्ध नहीं ।

(च) ६. रधिक for (रधिकं) ४ पश्चाद्युति for (पश्चाद्भुति)

५. व्यस्ता for (व्यस्ता)

(क) १. भक्तं for (भुक्तं) २. ग्रहान्तरं for (ग्रहान्तरं) ३. गतौ for (गतौ) ४. पश्चाद्युति for (पश्चाद्भुति)

५. व्यस्तम् for (व्यस्ता)

५. (घ) ३. वक्री (ग) (च) for (वक्रि)

४. पश्चाद्भुत्यात् for (पश्चात्)

(ग) १. युत्योनः for (युत्योनः)

२. प्रागथादधिकः पश्चात् for (प्रागथादधिकः । पश्चात्)

५. भक्ता for (भक्ताः)

६. भुक्ति (च) for (भुक्तिः) इस श्लोक की प्रथमपंक्ति का अन्तिम पद ‘पश्चात्’ है । अतः दूसरी पंक्ति ‘ग्रहयो’ से आरम्भ होती है ।

(च) २. प्रागथादधिकः for (प्रागथादधिकः)

(क) १. युत्येन for (युत्योनः) २. प्रागथादधिकः for (प्रागथादधिकः)

६. (घ) ३. वक्रिणि (ग) for (वक्रिणी)

२. पातेषु च (ग) for (पातेच)

४. व्यस्तः for (व्यस्तम्)

(क) १. ग्रहो for (ग्रहे) २. पातेषु च फलम् for (पाते च स्वफलम्)

बुधसितपाते व्यस्तं मन्दफलमुपान्त्यशीघ्रफलम् ।
 शेषाणां स्फुटपातात् विक्षेपो मध्यमात् योगात् ॥ ७ ॥
 मंदफलस्फुट शशिनो विक्षेपो भौमगुरुशशिनां च ।
 मंदफलव्यस्तस्फुटशीघ्रात् बुधशीघ्रयोरथवा ॥ ८ ॥
 समलिप्ता स्फुटमध्यात् स्वपातायुक्तात् ज्ञः शुक्रयोः शीघ्रात् ।
 जीवविक्षेपगुणा हतात्कर्णेन विक्षेपः ॥ ९ ॥

७. (घ) ४. विक्षेपोन्मध्यमात् (च) for (विक्षेपोमध्यमात्)
 ५. पातात् (ग) for (योगात्)
 (च) ४. विक्षेपोन् for (विक्षेपो)
 (क) १. सितपततै व्यस्तम् for (सितपातेव्यस्तं) २. सद for (मन्द) ३. मध्यमात्यात् for (मध्यमात्)
८. (घ) १. शनीनां (च) for (गुरुशशिनां च) (ग) जीवर विजानां for (गुरु-
 शशिनां च)
 ४. शीघ्राद्बुध (ग) for (शीघ्रात्बुध)
 ३. शुक्रयोरथवा (ग) for (शीघ्रयोरथवा)
 (ग) ५. शुक्रयोरथवा (ग) for (शीघ्रयोरथवा)
 (च) १. शनीनां for (शशिनां)
 २. शीघ्राद्बुधशुक्रयो for (शीघ्रात्बुधशीघ्रयो)
 'क' १. जीवरविजानां for (गुरुशशिनां च) २. फला for (फल) ३. शुक्रयो for (शीघ्रयो)
९. (घ) ३. समलिप्ता (ग) (च) for (समलिप्ता)
 ४. ज्ञशुक्रयोः (ग) (च) for (ज्ञः शुक्रयोः)
 १. जीवा विक्षेप (ग) (च) for (जीवविक्षेप)
 २. गुणाहतात्फ (ग) गुणाहतीत्य for (गुणाहतात्)
 (ग) ५. युक्ता for (युक्तात्)
 ६. विक्षेपाः for (विक्षेपः)
 (च) २. हतांत्य for (हतात्)
 (क) २. हतान्य for (हतात्)

अन्तरयोगो तुल्यान्यदिशोर्विक्षेपयोर्ग्रहांतरकं ।
 आर्यभटादिष्ट्वं समलिप्तिकयोर्गुतिर्ग्रहयोः ॥ १० ॥
 चित्रास्वातिवदुदयेऽन्यथान्यथास्ते तथायुतौ ग्रहयोः ।
 न भवति दृग्गणितैक्यं यथा तदैक्यं तदुक्तिरतः ॥ ११ ॥
 ग्रहयोः स्वोदयलग्ने समलिप्तिकयोस्तदस्तलग्ने च ।
 उदये स्वोदयलग्ने स्वषड्ग्रह स्वास्तलग्नसमे ॥ १२ ॥
 कृत्वेवं दिनघटिकाः ग्रहयोः स्वोदयविलग्नयोरूनं ।
 अनस्यास्तविलग्नोदेष्यताधिकं युतिरविता ॥ १३ ॥

१०. (घ) २. आर्यभटादिष्ट्वं (च) for (आर्यभटादिष्ट्वं)
 (ग) १. अन्तरयोगौ for (अन्तरयोगो)
 (च) १. योगौ for (योगो)
 (क) १. योगौ for (योगो) २. ष्वेवं for (ष्ट्वेवं)
११. (ग) ३. तदुक्तिरतः for (तदुक्तिरतः)
 (क) १. दयो for (दये) २. युतिः for (युतौ)
१२. (घ) ४. उदयैः (ग) for (उदये)
 (ग) ५. सषड्ग्रहे for (स्वषड्ग्रह)
 ६. स्वास्तमयलग्ने for (स्वास्तलग्नसमे)
 (च) ७. ग्रहयो for (ग्रहयोः) ४ उदयैः for (उदयै)
 (क) १. + स्फुट ग्रह युति संसाधनाय सम+ २. समा for (सम)
 ३. लग्नं for (लग्ने) ४. उदयैः for (उदये) ५. स for (स्व)
 ६. समो for (समे)
१३. (घ) १. ऊनस्वास्त (ग) ऊनं स्वास्त for (अनस्यास्त)
 २. देष्यत्यधिकं (ग) दिष्यत्यधिकं for (दिष्यतधिकं)
 ३. युतिरविता (ग) युतिरतीता for (युतिरविता)
 (ग) ४. कृत्वेवं for (कृत्वेवं)
 ५. लिलग्नयोरूनम् for (विलग्नयोरूनं)
 (च) ऊनस्वास्त for (अनस्यास्त)
 ३. रवीता for (रविता)
 (क) १. ऊनस्वास्त for (अनस्यास्त) २. त्यधिक for (तदधिकं)
 ३. रतीता for (रविता)

ऋणमूनं^२ धनमधिकं^१ स्वोदयलग्नात्^३ समस्तलग्नं^४ चेत्भक्ताः ।
 भक्ता स्तन्दरकलाः^२ पृथक्^३ पृथक्^४ स्वदिननाडिभिः ॥ १४ ॥
 ऋणयोर्वा^१ धनयोर्वान्तरेण^२ मुत्याधनार्णयोर्भक्ताः ।
 अन्तरलिप्ताः^३ स्वोदयविलग्नयोर्लब्धघटिकाभिः ॥ १५ ॥
 उदयास्तविलग्नान्तरकलागुणाः^४ स्वदिननाडिका भक्ताः ।
 लब्धकलादिकमूनं^१ स्वास्त विलग्नानुदयलग्नम् ॥ १६ ॥
 यद्यधिकमूनमेवं^२ समलिप्तौ^३ स्वोदयाद्युतौ^४ गृहयोः ।
 रात्रिविलग्नानुनावधिकौ^१ षड्ग्रहादृश्यौ ॥ १७ ॥

१४. (घ) १. स्वमस्त for (समस्त)
 २. तदन्तरकलाः for (तन्दरकलाः)
 (ग) ३. 'स्व' यह पद यहाँ अंकित नहीं ।
 (च) ४. 'भक्ताः' द्वितीय पंक्ति का "भक्तास्" रूप में आरंभिक शब्द है ।
 २. भक्तास्तदन्तर कलाः for (भक्तास्तन्दरकलाः)
 'क' २. स्वमस्त for (समस्त)
 (ग) २. तदन्तर कालाः for (तन्दरकलाः)
१५. (घ) ३. वोधनयो for (वर्धनयो)
 २. युत्या (ग) युत्तया for (मुत्या)
 (ग) ४. अन्तरलिप्ता for (अन्तरलिप्ताः)
 ५. स्वाद for (स्वोदय)
 (च) ३. वोधनयो for (वर्धनयो)
 १. वर्तरेण for (वर्न्तरेण)
 २. युत्या for (मुत्या)
 (क) १. वर्न्तरेण for (वर्न्तरेण) २. युत्तया for (मुत्या)
१६. (घ) २. नाडिकभक्ताः for (नाडिका भक्ताः)
 १. लब्धकलाधिकमूनं (च) for (लब्धकलादिकमूनं)
 (क) २. कलाधिकमूनं (कलादिकमूनं)
१७. (घ) १. षड्ग्रहयुताद् (ग) षड्ग्रहायुता for (षड्ग्रहा)
 (च) १. षड्ग्रहयुता for (षड्ग्रहा)
 (क) १. षड्ग्रहयुता for (षड्ग्रहा)

एवं मानैक्यार्द्धादधिके मध्यांतरे युतिर्ग्रहयोः ।
 स्थित्यर्द्धविमर्ददले हीनेतरा ग्रहेन्दुयुतौ ॥ १८ ॥
 लम्बनमकग्रहणवदसकृत्स्वावनतिलिप्तिकास्पष्टौ ।
 तात्कालिकविक्षेपौ तदन्तरैक्यं समान्यदिशोः ॥ १९ ॥
 विक्षेपो मध्यान्तरमुर्ध्वस्वच्छादको ग्रहोऽधस्थः ।
 मानैक्यार्द्धादधिके नातिस्पष्टास्फुटोक्तिरतः ॥ २० ॥

१८. (घ) ३. ताराग्रहेन्दुयुतौ (ग) for (तराग्रहेन्दुयुतौ)

(ग) ४. युतिग्रहयोः for (युतिर्ग्रहयोः)

(च) ५. विमर्द for (विमर्द)

(क) १. दधि for (दधिके)

२. स्थित्यर्ध for (स्थित्यर्द्ध)

३. तारा for (तरा)

१९. (घ) ३. तदन्तरेक्यम् for (तदन्तरैक्यम्)

(ग) ४. लिप्ता for (लिप्तिका)

(च) ५. मर्क for (मर्क)

(क) १. वत् for (वद)

२. दश कृत for (दसकृत्)

३. तदन्तारैक्यम् for (तदन्तरैक्यम्)

२०. (घ) १. मूर्ध्व स्वच्छादको ग्रहोऽधस्थः (ग) मूर्धस्य छादको ग्रहोऽधस्थः for (मुर्ध्वस्वच्छादको ग्रहोऽधस्थः)

(च) १. मूर्ध्व for (मुर्ध्व)

२. अधस्थ for (ऽधस्थः)

(क) १. मूर्धस्य for (मुर्ध्वस्य)

२. अधः स्थः for (ऽधस्थः)

ऊनदिनोदितगुणितादधिका^४ दिनादूनदिनाहृतालब्धम्^३ ।
 अधिकं प्राग्युतिरूनं यद्यधिकं^३ दिनोदिनात्पश्चात् ॥ २१ ॥
 अन्तरमाद्यो^१ भूयो^२ यदिष्टघटिका^३ फलोन्युतयोश्च ।
 प्राक्पश्चाद्द्वान्तरयोस्तदन्तरेणोद्धृता^४ तदाद्यात् ॥ २२ ॥
 युतान्यथेष्ट^३ घटिका^४ गुणितात्फलनाडिकाभिराद्यवशात् ।
 प्राक्^३ समलिप्तिकलात्पश्चाद्वा ग्रहयुतिर्भवति ॥ २३ ॥
 स्वदिनघटिका^३ विभक्तस्तदुदितपरदिवसनाडिकाद्यात् ।
 तुल्यः परोदिताभिर्घटिकाभिर्यदियुतिर्^३ ह्योः ॥ २४ ॥

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२१. (घ) ३. अधिक दिनादूनदिनाहृतालब्धम् (ग) for (अधिकादिनादूनदिनाहृतालब्धम्)
 (ग) ४. गुणिताद् for (गुणिताद्)
 २. दिनोदिनात्पश्चात् for (दिनोदिनात्पश्चात्)
 (च) ३. दधिकदिना for (दधिकादिना)
 १. दूनदिनाहृतालब्धं for (दूनदिनाहृतालब्धं)
 (क) १. हृतालब्धम् for (हृतालब्धम्) २. सदिनोदिनात्पूर्वं for (दिनोदिनात्पश्चात्)
२२. (घ) १. अन्तमाद्यो for (अन्तरमाद्यो)
 (ग) २. न्यदिष्टघटिका for (यदिष्टघटिका)
 ४. तदन्तरेणोद्धृता for (तदन्तरेणोद्धृता)
 ५. दाद्यात् for (तदाद्यात्)
 (क) १. नाद्यं for (माद्यो) २. अन्यदि घटिका for (यदिष्टघटिका)
 ३. पश्चात् ॥ द्वयन्तरयोः for (पश्चाद्द्वान्तरयोस्) ४. तदन्तरे for (तदन्तरे)
 ५. दाधान for (तदाद्यात्)
२३. (घ) १. युत्तान्यथेष्ट (ग) युत्तान्यथेष्ट for (युत्तान्यथेष्ट)
 ३. लिप्तिक कालात् (ग) for लिप्तिकलात्)
 (च) १. युत्तान्यथेष्ट for (युत्तान्यथेष्ट)
 १. द्युत्तान्यथेष्ट for (युत्तान्यथेष्ट) २. ऽराद्यवशात् for (राद्यवशात्)
 (क) ३. लिप्तिक कालात् for (लिप्तिकलात्)
२४. (ग) ३. विभक्तात्तदुदित for (विभक्तस्तदुदित)
 १. घातः for (घात्)
 (क) १. घातः for (घात्) २. परोदितताभि for (परोदिताभि)

विक्षेपमानसमकलदिनघटिकाः स्वोदयास्तलग्नाद्यैः ।

(पंचविंशति) षड्विंशति^३ आर्याणां नवमो गृहमेलकोऽध्यायः ॥ २५ ॥

इति ब्रह्मगुप्ते नवमोऽध्यायः ॥

२५. (घ) २. षड्विंशत्यार्याणां (च) for (पंचविंशति आर्याणां)

(ग) ३. घटिका for (घटिकाः)

दूसरी पंक्ति निम्नांकित है—

‘नवमोऽध्यायोऽग्रहयुतिराय्याणां पंचविंशत्याः’ for (पंचविंशति आर्याणां नवमो-
ग्रहमेलकोऽध्यायः)

(च) ४. श्रीः for (“इति...नवमोऽध्यायः”)

(क) १. सकल for (समकल)

२. पंचविंशत्यार्याश्च for (पंचविंशति आर्याणां)

अष्टनखैर्मेषगविरदलिप्तोनै गुणैः^१ स्वरै^२ मिथुने ।
 कर्कटके गुणषोडशं धृतिभिः^३ सिंहेन व^४ त्रिघनैः ॥ १ ॥
 कन्यायां पंचनखैस्तुलिनि अधिधृतिभिरलिनी सेषुकाले ।
 द्विचतुर्दशाति धृतिभि^५ धनुषि शंशाक मनुतत्त्वैः^६ ॥ २ ॥

१. (घ) ५. मोखग (ग) मोषग for (मेषग)
 १. लिप्तोनैर्गण (ग) लिप्तोनैर्गुण for (लिप्तोनैर्गुणैः)
 २. स्वस्वरैर्मिथुने (ग) for (स्वरै मिथुने)
 ६. धृतिभि (च) for (धृतिभिः)
 ७. च (च) for (व)
- (ग) ३. कर्कटके गुणषोडश for (कर्कटके गुणषोडशं)
 ४. त्रिघनैः for (त्रिघनैः)
- (च) ५. मेषे for (मेष)
 १. गुणस्वरैर्मिथुने for (गुणैः स्वरैर्मिथुने)
 ८. षोडश for (षोडशं)
 ४. त्रिघनैः for (त्रिघनैः)
- (क) १. गुण for (गुणैः)
 ३. कर्कटे for (कर्कटके)
 ४. त्रिघनैः for (त्रिघनैः)
२. (घ) १. त्र्यतिधृतिभिरलिनि सेषुकालेः (ग) त्र्यतिधृतिभिरलिनिसेषुकलैः for (अधिधृतिभिरलिनी । सेषुकाले)
 ४. धृतिभिर्धनुषि (ग) (च) for (धृतिभिर्धनुषि)
 ३. मनुखतत्त्वै (ग) मनुखतत्त्वैः for (मनुतत्त्वैः)
- (ग) २. द्विचतुर्दशानि for (द्विचतुर्दशाति)
- (च) १. अतिधृ तिभि रलिनि (अधिधृतिभिरलिनी)
 ५. क्रमसंख्या लुप्त
- (य) १. त्र्यतिधृतिभि रलितेषुकलैः for (अधिधृतिभिरलिनी सेषुकालैः)
 २. दशा त्रिधृतिः for (दशातिधृतिभिः)
 ३. मनुनखै तत्त्वैः for (मनुतत्त्वैः)

भकरेष्टनखैः कुम्भे नखषड्विंशैः ऋणैः मुनित्रिंशैः ।
 पृथगश्विन्यादीनां ध्रुवकाशैर्योगताराश्वैः ॥ ३ ॥
 ध्रुवकादूनः पश्चादधिकः प्राग्वत् कृतेऽन्यथायोगः ।
 अन्यत् ग्रहमेकवत् ध्रुवक्रान्तेर्भविक्षेपाः ॥ ४ ॥
 सौम्यादशार्कविषया याम्या शरदशभवारसासौम्याः ।
 खसप्त दक्षिणाः खं सौम्याः सूर्य त्रयोदशकाः ॥ ५ ॥

३. (घ) ४. नखषड्विंशैः for (नखषड्विंशैः)
 १. भषे (ग) भषे for (ऋणैः)
 ५. मुनित्रिंशैः for (मुनित्रिंशैः)
 २. ध्रुवकाशैः (ग) (च) for (ध्रुवकाशैः)
 (ग) ३. श्वैः for (श्वैः)
 (च) १. भषे (ऋषे) for (ऋणैः)
 ५. मुनित्रिंशैः ॥३०७॥ for (मुनित्रिंशैः)
 ३. योगताराश्वैः for (योगताराश्वैः)
 (क) १. भषे for (ऋणैः) २. काशैः for (काशैः) ३. चैष्ट for (श्वैः)
४. (घ) २. प्राग्वत्कृतेन्यथायोगः (ग) प्राग्वत्कृतेऽन्यथायोगः for (प्राग्वत्कृतेऽन्यथायोगः)
 ३. ध्रुवक्रान्तेर्भ for (ध्रुवक्रान्तेर्भ)
 (ग) ४. दूनैः for (दूनैः)
 ५. दधिके for (दधिकः)
 १. अन्यद्ग्रहमेकवत् ध्रुवक्रान्तेर्भविक्षेपः for (अन्यद् ग्रहमेकवत् ध्रुवक्रान्तेर्भविक्षेपाः)
 (च) २. अवग्रहचिह्नलुप्त १. अन्यद्ग्रह for (अन्यद्ग्रह)
 ३. ध्रुवक्रान्ते for (ध्रुवक्रान्ते) ६. विसर्गलुप्त
५. (घ) ४. षं (ग) खं for (खं)
 (ग) १. याम्याः for (याम्या)
 २. ३. शरदिग्भवारसाः for (शरदशभवारसाः)
 ५. सौम्यां for (सौम्याः)
 (च) ६. दशार्क for (दशार्क) ४. षंसप्त for (खसप्त)
 (क) १. याम्याः for (याम्या) २. सर for (शर) ३. दिग् for (दश)
 ४. खं for (ख)

दक्षिणतोभयमलाः सप्त त्रिंशदुदगंशका याम्याः ।
 अध्यर्धत्रिचतुष्काद्धं नवमसप्तत्रिंशविषयशराः ॥ ६ ॥
 सौम्याद्विधिका यष्टि त्रिंशत् षट्त्रिंशदितरतो लिप्ताः ।
 अष्टादशोत्तरजिनाः षड्विंशत्यंतराण्यंशाः ॥ ७ ॥
 प्राजेशयोगन्तरा विक्षेपांशैः कलात्रिघनहीनैः ।
 आग्नेयस्य कलामेकोन त्रिंशताहीनैः ॥ ८ ॥

६. (घ) ३. अमला for (यमलाः)
 ४. शरा (च) for (शराः)
 (ग) १. भव for (भ)
 २. सत्र्यंश for (सप्तत्रिंश)
 ५. विखय for (विषय)
 (च) ३. विसर्गलुप्त ६. अध्यर्धं for (अध्यर्धं)
 (क) १. भव for (भ) २. शशंश (शत्र्यंश) for (सप्तत्रिंश)
 ७. (घ) १. सौम्याद्विधिका (ग) (च) for (सौम्याद्विधिका)
 ३. षष्टि (ग) for (यष्टि)
 ५. षड्विंश for (षट्त्रिंश)
 ६. षड्वचंश त्र्यंतराण्यंशाः for (षड्विंशत्यंतराण्यंशाः)
 (ग) ७. त्रिंशत् for (त्रिंशत्)
 (च) २. षष्टि for (यष्टि) ७. त्रिंश for (त्रिंशत्)
 ५. षड्विंश for (षट्त्रिंश)
 ६. षड्वचंशत्यंतराण्यंशाः for (षड्विंशत्यंतराण्यंशाः)
 (क) १. सौम्याद्विधिका for (सौम्याद्विधिका) २. षष्टि for (यष्टि) ३. दिव for (दित)
 ४. बराण्यंशाः (ग) for (तराण्यंशाः)
 ८. (घ) १. योगतरा (ग) योगतारा for (योगन्तरा)
 ३. विक्षेपांशैः (ग) for (विक्षेपांशैः)
 (ग) ४. आग्नेयस्य for (आग्नेयस्य)
 (च) १. योगतारा for (योगन्तरा) ३. विक्षेपांशैः for (विक्षेपांशैः)
 ५. + २७+ ६. + ३०+
 (क) १. योगतारा for (योगन्तरा)
 २. कलामेकोन (ग) for (कलामेकोन)

पंचदशकला हीनैश्चित्रायाः सप्ततिविशाखायाः ।
 षट् सप्तत्या मैत्रस्यैन्द्रस्य त्रिशता हीनैः ॥ ९ ॥
 छादय योगतारां मानाद्धोनाधिकाद् विक्षेपात् ।
 स्फुट विक्षेपो यस्याधिकोनको भवति समदिक्सु ॥ १० ॥
 विक्षेपोऽंश द्वितीयादधिको वृषभस्य सप्तदशभागे ।
 यस्य गृहस्य याम्यो भिनत्ति शंकट स रोहिण्याः ॥ ११ ॥

९. (घ) ३. विशाखायाः (च) for (विशाखायाः)

४. मैत्रसौन्द्रस्य (ग) मैत्रस्येन्द्रस्य for (मैत्रस्यैन्द्रस्य)

(ग) २. सप्तभि for (सप्तति)

(च) ५. + ३० +

(क) १. श्चित्रायाः for (श्चित्रायाः)

२. सप्तभिः for (सप्तति)

१०. (घ) २. भविक्षेपात् (ग) भवति विक्षेपात् for (विक्षेपात्)

३. समदिक्सुः for (समदिक्सु)

(ग) १. छादयति for (छादय)

(च) २. भविक्षेपात् for (विक्षेपात्)

३. समदिक्सुः for (समदिक्सु)

(क) १. छादयसि for (छादय)

२. भविक्षेपात् for (विक्षेपात्)

३. दिक्स्थः (ग) for (दिक्सु)

११. (घ) ३. विक्षेपोऽंश for (विक्षेपोऽंश)

४. द्वितीयादधिको (ग) (च) for (द्वितीयादधिको)

(ग) १. वृषस्य for (वृषभस्य)

५. रोहिण्या for (रोहिण्याः)

(च) २. शकटं for (शंकट)

(क) १. मृषभस्य for (वृषभस्य)

२. शकटं (ग) for (शंकट)

विक्षेपे^१त्ये सौम्ये^४ तृतीयतारां^५ भिनत्ति^६ पित्र्यस्य^७ ।

इन्दु^८भिनत्ति^९ पुष्पं^{१०} पौष्णं^{११} वारुणं^{१२}मविक्षिप्तः ॥ १२ ॥

कृत्वापि^{१३} दृष्टिकर्म^{१४} श्रीषेणाचार्यभट^{१५} विष्नुचन्द्रोक्तम्^{१६} ।

प्रतिदिनमुदये^{१७}स्ते वा न भवन्ति^{१८} दृग्गणितयोरैक्यम्^{१९} ॥ १३ ॥

१२. (घ) १. विक्षेपो^१त्ये for (विक्षेपे^१त्ये)

४. सौम्ये^४ । २७० । (च) for (सौम्ये)

५. भिनत्ति^५ for (भिनत्ति)

६. इन्दु^८भिनत्ति^९ (ग) (च) for (इन्दु^८भिनत्ति)

(ग) ७. त्र्यस्य^७ for (पित्र्यस्य)

(क) १. विक्षेपो^१त्ये for (विक्षेपे^१त्ये)

२. पुष्पं^{१०} for (पुष्पं)

३. वारुणं^{१२} for (वारुणं)

१३. (घ) ३. विष्णु^{१३} (ग) (च) for (विष्णु)

५. मुदये^{१७}स्तेवा^{१८} (ग) for (मुदये^{१७}स्तेवा^{१८})

४. भवति^{१८} (ग) (च) for (भवन्ति)

(ग) ६. कृत्वा^{१३} (यहां 'अपि' नहीं है) for (कृत्वापि)

२. श्रीषेणार्थ^{१५}भट^{१६} for (श्रीषेणाचार्यभट)

७. दृग्गणितरैक्यम्^{१९} for (दृग्गणितयोरैक्यम्)

(च) ८. प्रतिदिन^{१७} for (प्रतिदिन) ५. मुदये^{१७}स्ते for (मुदये^{१७}स्ते)

(क) १. कर्म^१ for (कर्म)

२. श्रीषेणार्थ^{१५} for (श्रीषेणाचार्य)

३. विष्णु^{१३} for (विष्णु)

४. भवति^{१८} for (भवन्ति)

भमुनिमृगव्याधानां यतस्तददृष्टिकर्म वक्ष्यामि ।

दृग्गणित समदेयं शिष्याय चिरोषितायेदम् ॥ १४ ॥

अ	भ	कु	रो	मृ	आ	पु	पु	अ	म	पू	उ	ह	चि	स्वा	वि	अ	जे	र
००	००	१	१	२	२	३	३	३	४	४	५	५	६	६	७	७	७	८
८	२०	७	१६	३	७	३	१६	१८	६	२७	५	२०	३	१६	२	१४	१६	१
००	००	२८	२८	००	००	००	००	००	००	००	००	००	००	००	००	००	००	००
००	००	००	००	००	००	००	००	००	००	००	०२	००	००	००	००	००	००	००

श	उ	अ	अ	ष	श	पू	उ	रे
८	८	८	६	६	१०	१०	११	१२
१४	२०	२५	८	२०	१०	२६	७	००
००	००	००	००	००	००	००	००	००
००	००	००	००	००	००	००	००	००

१.४ (घ) १. ततो (च) त for (तद)

१. ज्ये ३. मू ६. पू

३. वक्षामि (ग) कक्षामि for (वक्ष्यामि)

७
१६ ४. पू
५
०

४. समं (च) for (सम)

७. वि ८. अ० ५. श.

(ग) ५. दृष्टिकर्म for (दृष्टिकर्म)

७ ७ १०
२ १४ २६
५ ५ ०

२. दस्यात्र for (दृग्गणित)

० ०

६. विरोषितायेदम् for (चिरोषितायेदम्)

(च) ७. व्याख्यानां for व्याधानां ३. वक्षामि for वक्ष्यामि

८. शिष्याय for (शिष्याय)

(क) १. ततो for (तद) २. न माणित for (दृग्गणित)

(च) ७. वि. ८. अ. १. ज्ये० ३. मू for (र) ४. पू for (श) ५. श०

७	७	१	८	८	१०
२	१४	१६	१	१४	२६
५	५	५	०	०	०
०	०	०	०	०	०

(११६)

(घ) केवलमात्र परिवर्तित रूप—शेष सब ठीक है।

વિ. જ્યે. ૩. મૂ. ૪. શ. ૫. શ. ૬. પૂ.

၆	၆	၇	၇	၉၀
၃	၉၉	၉	၉၈	၃၆
၄	၄	၀	၀	၀
၀	၀	၀	၀	၀

अतिरिक्त —

विक्षेपाः

अ	भ	कु	रो	सृ	आ	पु	पु	अ	म	पू	उ	ह	त्रि
१०	१२	५	५	१०	११	६	०	७	०	१२	१३	१३	२
१													
स्वा	वि	अ	ज्ये	सू	पू	उ	उ	अ	घ	श	पू	उ	रे
२७	१	०	४	५	५	५	१२	३०	२६	०	२४	२६	०
	३०			२०	२०				१८				

(ग) अश्विन्यादिध्रुवकाः

अ	भ	क	र	ॐ	आ	पु	पु	अ	म	पू	उ	ह	वि
०	०	१	१	३	२	३	३	३	४	४	५	५	६
८	२०	७	२६	०	७	३	१६	१०	६	२७	५	२०	३
		२८	२८			०	०	०	०	०	०	०	०

[illegible]

क्रांतिज्या^१ तत्क्रान्तिविक्षेप^५क्रान्तिचापानाम् ।

संयोगान्तरजीवा स्वक्रान्तिज्यैकभिन्नदिशां ॥ १५ ॥

एवं भमुनिध्रुवयो^१ ग्रहतत्क्रान्त्या चन्द्राष्टकं^२ कर्माद्यं ।

कृत्वा ग्रहे भमुनिवत् तस्मात्स्वक्रान्ति जीवा वा ॥ १६ ॥

१५. (घ) २. चापभागानाम् (ग) for (चापानाम्)

(ग) ५. विक्षेप for (विक्षेप)

६. दिशोः for (दिशां)

(च) २. चापनां for (चापानां)

६. चैकभिन्नदिशां for (ज्यैकभिन्नदिशां)

(क) १. क्रांति ज्यतिक्रांति for (क्रान्तिज्यातत्क्रान्ति)

२. चापभोगानां for (चापानाम्)

३. संयोगांचर for (संयोगान्तर)

४. क्रातज्यैः कविभिर्मादिशाम् for (क्रातिज्यैकभिन्नदिशाम्)

१६. (घ) १. ध्रुवयोर्ग्रह for (ध्रुवयोर्ग्रह)

२. च दृष्टि कर्माद्यं (ग) for (चन्द्राष्टकं कर्माद्यं)

(ग) १. एवं भमुनेध्रुवयोर्ग्रहतत्क्रान्त्या for (एवं भमुनिध्रुवयोर्ग्रहतत्क्रान्त्या)

३. च for (वा)

(च) २. च दृष्टि for (चन्द्राष्टकं)

(क) १. भमुनिध्रुवका प्राक् प्रदर्शिता त्विषा ।

सेषामेवकार्यं ग्रहस्य पुनातत् क्रान्ते प्रथमं वृत्तरां

कृत्वा पश्चात् तज्ज्ञाति स्वक मुनिध्रुवकवत् ।

for

एवं भमुनिध्रुवयो ग्रहतत्क्रान्त्या चन्द्राष्टकं कर्माद्यं ।

कृत्वा ग्रहे भमुनिवत् तस्मात्स्वक्रान्ति जीवा वा ॥ १६ ॥

त्रिज्याप्तां^१शुभिरुदयैर्धाता द्विक्षेप^५ सत्रिभक्रान्त्ये ।
 ऋणधनमेकान्यदिशोस्तयोर्^४हेन^४ भमुनि ध्रुवके ॥ १७ ॥
 तत्स्वक्रान्तिज्याभ्यां चन्द्रादीनां पृथक् चरप्राणान् ।
 कृत्वा^३कैवत्तदंतरसंयोगो तुल्यभिन्नदिशाम्^२ ॥ १८ ॥
 तत्प्राणैर्विक्षेपे सौम्ये हीनो गृहोऽधिके^३ याम्ये ।
 उदयैर्भद्रुवको वागस्त्यध्रुवकोऽथवा लग्नम् ॥ १९ ॥

१७. (घ) ५. द्विक्षेप for (द्विक्षेप)
 २. क्रान्त्यो (ग) क्रान्त्योः for (क्रान्त्ये)
 (ग) १. त्रिज्याप्ताशुभिरुदयैर्धाता ३२७० for (त्रिज्याप्तांशुभिरुदयैर्धाता)
 ३. ऋणधन for (ऋणधन)
 (च) इस प्रति में यहां 'विक्षेप' शीर्षक से अतिरिक्त निम्न सारणी दी गई है ।

विक्षेपाः

अ	भ	कृ	रो	मृ	आ	पु	पु	अ	म	पु	उ	ह
१८	१२	५	५	१०	११	५	०	७	०	१२	१३	१३
												१

चि०	स्वा.	वि	अ	ज्ये	भू	पू	उ	उ	अ	ध	श	पू	उ	रे
२	२७	१	०	४	५	५	५	१२	३०	३५	०	२४	२६	०
			३०			२०	२०				१८			

- (क) १. शुभिरुदयै for (शुभिरुदयै) २. भक्तम् for (क्रान्त्ये)
 ३. कर्णमनसे काम्य for (ऋणधनमेकान्य)
 ४. ग्रहेण for (ग्रहेण)
 १८. (घ) १. संयोगौ (ग) संयोगस् for (संयोगो)
 (च) ३. कृत्वा^३ for (कृत्वा^३)
 (क) १. संयोगौ for (संयोगो)
 २. दिशम् for (दिशाम्)
 १९. (घ) ३. ग्रहोधिको याम्ये (ग) (च) for (ग्रहोऽधिके)
 ४. ध्रुवकोथवा लग्नम् (ग) (च) for (ध्रुवकोऽथवा लग्नम्)
 (क) १. तत्क्रान्ति ऋणो for (तत्प्राणै)
 २. हीने for (हीनो)

उदये गृहभमुनीनामस्तमये षड्ग्रहाधिकः सौम्ये ।
 अधिको याम्ये हीनः षड्राशियुतोस्तमयलग्नम् ॥ २० ॥
 उदयविलग्नादधिके षड्राशियुतास्ते लग्नतो हीने ।
 रात्रिविलग्ने दश्यादिनेऽपि चन्द्रोन्यथा दृश्यः ॥ २१ ॥
 प्रागुदय लग्न मूनं लग्नादधिकं ग्रहोदयः पश्चात् ।
 ऊनमधिकेन तुल्यं कृत्वा घटिकाः स्वराश्वुदयैः ॥ २२ ॥
 प्रागस्तमयो लग्नादूनं षड्ग्रहयुतोस्तमयलग्नम् ।
 अधिकं पश्चात् घटिकाः कृत्वा सममूनमधिकं चेत् ॥ २३ ॥

२०. (घ) २. षड्ग्रहाधिकः (ग) (च) for (षड्ग्रहाधिकः)

(ग) ३. मुनीनां for (मुनीना)

४. स्तमयलग्नम् for (स्तमयलग्नम्)

(क) १. इक्कर्म कार्यम् for (सौम्ये)

२१. (घ) २. त (ग) (च) for (ते)

१. दृश्यो दिनेपि (ग) दृश्यो दिनेऽपि for (दश्यादिनेऽपि)

(घ) ३. षड्राश for (षड्राशि)

(च) ४. लग्नातो for (लग्नतो) ।

(क) दश्यादिनेपि for (दश्यादिनेऽपि)

२२. (च) १. राश्वुदयो for (राश्वुदयैः)

२३. (घ) १. षड्ग्रह (ग) (च) for (षड्ग्रह)

२. युतास्तमय (ग) for (युतोस्तमय)

४. पश्चाद्घटिकाः (ग) for (पश्चात्घटिकाः)

(ग) ३. अधिकेन for (अधिकं चेत्)

(च) ५. दूनं for (दूनं)

४. पश्चाद्घटिकाः for (पश्चात् घटिकाः)

६. कृत्वा for (कृत्वा)

(क) १. षड्ग्रह for (षड्ग्रह)

२. युतास्तमय for (युतोस्तमय)

३. अधिकेन for (अधिकं चेत्)

तात्कालिकोपकरणैः सङ्क्रुदागतनाडिकाभिरह्नीदौ ।
 रात्रौ वा प्रति घटिकं प्राग्वच्छङ् गोन्नतिः धार्या ॥ २४ ॥
 मध्यछाया रविवत् स्वक्रान्त्या दर्शनेमनीष्टाच ।
 एवं भ मुनीनामन्तर घटिका गुणं भुक्तिः ॥ २५ ॥
 दृष्ट्या विभजेत् लब्धं प्रागुदयास्तमययोः गृहे शोध्यम् ।
 पश्चात् क्षेप्यं प्रतिदिनमुदयस्तमयासङ्क्रुदेवं ॥ २६ ॥

२४. (घ) १. रह्नीदौ (ग) रह्नीदोः for (रह्नीदौ)
 ४. कार्याः (च) for कार्या
 (ग) १. सङ्क्रुतागत for (सङ्क्रुदागत)
 ५. तात्कालिकोपकरणैः for (तात्कालिकोपकरणैः)
 (क) १. शङ्क्रुद् for (सङ्क्रुदागत) २. रह्नीदोः for (रह्नीदौ) ३. रात्रौ for (रात्रौ)
 ३. घटिका for (घटिकं)
२५. (घ) ३. क्रान्त्या for (क्रान्त्या)
 १. सतीष्टा (ग) सती च for (मनीष्टा)
 ५. एवं ग्रह (ग) for (एवंभ)
 ६. मनीना (ग) मुनीना for (मुनीना)
 ७. गुणां for (गुणं) (ग) गुणाभक्तम् for (गुणं भुक्तिः)
 (च) १. सतीष्टा for (मनीष्टा)
 ५. एवंग्रह for (एवंभ)
 (क) १. सतीष्टा for (मनीष्टा) २. ग्रह for (भ) ३. भुक्तिम् for (भुक्तिः)
२६. (घ) ३. विभजेत्लब्धं (ग) for (विभजेत्लब्धं)
 ४. ग्रह (ग) ग्रहे (च) for (ग्रहे)
 ५. उदयास्त (ग) for (उदयस्त)
 ६. मयावसङ्क्रुदेवं (ग) for (मयासङ्क्रुदेवं)
 (च) ३. विभजेत्लब्धं for (विभजेत्लब्धं)
 ७. विसर्गलुप्त
 १. पश्चाक्षेप्यं for (पश्चात्क्षेप्यं)
 ६. मयावसङ्क्रुदेवं for (मयासङ्क्रुदेवं)
 (क) ६. क्षेप्यत्र for (क्षेप्यं)
 २. सङ्क्रुदवम् for (सङ्क्रुदेवं)

इष्टात्कालात्^२ भानोरुदयास्ताद्वा गृहोदयास्तमयैः ।
 तात्कालिकं^३ विलग्नगृहोदयास्तमयलग्नाद्यैः ॥ २७ ॥
 प्रागुदयलग्नमुदयैर्लग्नसमं^४ लग्नमुदयलग्नेन ।
 पश्चात्^५ तत् घटिकाभिः कृत्वा तात्कालिकैरसकृत् ॥ २८ ॥
 उदयं प्रागस्तमयो लग्नेन पश्चानपङ्गुहास्तमयः ।
 लग्नं पश्चाल्लग्नचक्राद्धं^६ संयुतास्तमये लग्नेन ॥ २९ ॥
 उनोल्पभुक्तिरुदितः प्रागथवो^७ देष्यति गृहः सूर्यात् ।
 पश्चादधिकोधिकगतिरल्पगती वक्रितौ जसितौ ॥ ३० ॥

२७. (घ) २. कालाद्भानो (ग) (च) for (कालात् भानो)

१. मयै (ग) मयौ for (मयैः)

३. विलग्न (ग) (च) for (विलग्नं)

(ग) ४. इष्टा for (इष्टात्)

५. होदयास्तमय.....for (ग्रहोदयास्तमय)

(च) १. मयै for (मयैः)

(क) १. मयौ for (मयैः)

२८. (घ) ३. पश्चात्तद्धटिकाभिः for (पश्चात् तत् घटिकाभिः)

५. पश्चात्त for (पश्चात् तत्)

(च) ५. पश्चाद्धटिकाभिः for (पश्चात्तत् घटिकाभिः) ६ कृत्वा for (कृत्वा)

(क) १. मदयै for (मुदयै) २. मदय for (मुदय)

२९. (घ) १. सषड्गृहास्तमयलग्नम् (ग) (च) for (पश्चानपङ्गुहास्तमयः । लग्नम्)

३. पश्चाल्लग्नं (ग) for (पश्चाल्लग्नं)

(ग) ४. उदयः for (उदयं)

२. मय for (मये)

(क) १. सषड् गृहास्तमय लग्नम् for (पश्चानपङ्गुहास्तमयः लग्नम्)

२. मय for (मये)

३०. (घ) १. उनोल्पभुक्तिरुदितः (ग) (च) for (उनोऽल्पभुक्तिरुदितः)

(क) १. दर्ष्यति for (देष्यति)

प्रागूनाधिकभुक्तिः पश्चादधिकोत्पभुक्तिरस्तमितः ।
 यास्यत्यथवास्तमयं यतस्ततो दृश्यघटिकोक्तिः ॥ ३१ ॥
 घटिकाद्वयेन चन्द्रो दृश्योक्तात् सितगुरुज्ञ शनिभौमाः ।
 अर्ध्यर्द्धया घटिकाया त्रिभागघटिको ज्ञ (त्त) राधिकाया ॥ ३२ ॥
 गृहसूर्यान्तरघटिका स्वभुक्ति लिप्तानि स्वनयुतयोश्च ।
 प्राग्वदनंतर हताहीनाधिकनाडिका दिवसाः ॥ ३३ ॥

चं	शु	बृ	बु	श	मं
२	३०	१	२	१	२
००	००	५०	००	३०	५०

३१. (घ) १. प्रागूनाधिकभुक्तिः for (प्रागूनाधिकभुक्तिः)
 (क) २. स्तमितः for (स्तमितः)
 ३२. (घ) १. घटिकाया (ग) (च) for (घटिकाया)
 ३. घटिकोत्तराधिकया (ग) (च) for (घटिकोत्तराधिकया)
 (ग) ४. अर्ध्यर्द्धय for (अर्ध्यर्द्धया)
 (च) ५. दृश्योक्तात् for (दृश्योक्तात्)
 (क) १. शित for (सित) २. घटिकाया for (घटिकाया) ३. शशिकोत्तरा for (घटिकोत्तरा)

७

३३. (घ) ४. घटिकाः (ग) (च) for (घटिका)
 ५. स्वनयुतयोश्च (च) for (स्वनयुतयोश्च)

चं.	शु०	बृ०	बु०	श०	मं
३	१	१	२	२	२
	३	५०	१०	३०	५०

२. प्राग्वदनंतर (च) for (प्राग्वदनंतर)
 ३. हता (ग) कृता for (हता)
 ६. दिवसा (च) for (दिवसाः)
 (ग) ८. युतयोरश्च for (युतयोरश्च)
 (च) ३. हता for (हता)
 (क) १. लिप्तानिस्वन for (लिप्तानिस्वन)
 (ग) २. तदनंतर for (दनंतर)
 ३. हवा for (हता)

७

चं	शु०	बृ०	बु०	श०	मं०
३	१	१	२	२	२
	३	५०	१०	३०	५०

विपरित^६धनमृणं^९ सौम्यशुक्रयोर्विक्रिणोः^७ स्वभुक्तिकलाः^८ ।
 एवमुदयास्तमययो विपरितं विक्रिणः^७ स्वफलम् ॥ ३४ ॥
 विक्षेपो^१ दक्षिणतस्तक्रांते^३भागि सप्तसप्तत्या ।
 मिथुनस्य सप्तविंशे भागेनस्त्योन्नतैर्भागैः ॥ ३५ ॥

३४. (घ) ६. विपरीत (ग) for (विपरित)

७. विक्रिणोः for (विक्रिणोः)

३. एवमुदयास्तमययो (ग) एवमुदयास्तमययो for (एवमुदयास्तमययो)

८. विपरीतं (ग) for (विपरितं)

(ग) १. ऋणधनं for (धनमृणं)

(च) ७. विक्रिणो for (विक्रिणोः)

८. विपरितं for (विपरितं)

(क) १. ऋणधनं for (धनमृणं)

२. कालः for (कलाः)

२. उदक for (उदया)

४. विक्रिण (ग) for (विक्रिणः)

५. फलाम् for (फलम्)

३५. (घ) १. विक्षिप्तो (ग) for (विक्षेपो)

२. वक्रांते (ग) तत्क्रान्ते for (तक्रान्ते)

३. नस्त्योन्नतैर्भागैः (ग) गस्त्योन्नतैर्भागैः for (नस्त्योन्नतैर्भागैः)

(ग) ४. 'सप्त' यह पद यहां अंकित नहीं ।

(च) १. विक्षेपो for (विक्षेपो)

२. तत्क्रांते for (तक्रान्ते)

३. नस्त्योन्नतैर्भागैः for (नस्त्योन्नतैर्भागैः)

(क) १. विक्षिप्तो for (विक्षेपो)

२. स्व for (स्त)

३. भागेरगेस्त्योन्नतैः for (भागेनस्त्योन्नतैः)

नवतेस्तनेह^१श्यो घटिकाद्वितयेन^३ तदुदयविलग्नम्^२
 उदयरधिकं^४ कृत्वा^५ तदुदयसूर्योस्तमयलग्नम् ॥ ३६ ॥
 षड्भयुतमूनमुदयैः^६ षड्राशियुतं^७ तदस्तमयसूर्यः^८ ।
 घटिकाद्वितयेनैवं^९ षड्भागयुतेन^{१०} मृगेहंतु ॥ ३७ ॥
 एवं नक्षत्राणां^{११} घटिकाद्वितयेन^{१२} सत्रिभागेन ।
 उदयाकोस्तमयाकां^{१३} व्यस्तोनस्तत्सदादृश्यम् ॥ ३८ ॥

३६. (घ) १. रूनैहश्यो (ग) रूनैहश्यो for (स्तनैहश्यो)

३. ६० घटिका for (घटिका)

(ग) ४. तदुदय for (तदुदय)

(घ) ५. रूनैहश्यो ६० for (स्तनैहश्यो)

६. रुदयै for (उदयै) ७. कृत्वा for (कृत्वा)

(क) १. रूनै for (स्तनै) २. विलग्नम् for (तदुदयविलग्नम्)

३७. (घ) २. तदस्तमसूर्यः for (तदस्तमयसूर्यः)

३. घटिद्वितयेनैवं for (घटिद्वितयेनैवं)

४. षड्भागयुतेन (च) for (षड्भागयुतेन)

(ग) ५. भाद्वयुत for (षड्भयुत)

६. हंतुः for (हंतु)

(च) ७. मृगेहंतु for (मृगेहंतु)

(क) १. रासि for (राशि)

३८. (घ) १. सत्रुभागेन (च) for (सत्रिभागेन)

३. व्यस्योनस्तत्सदा (च) for (व्यस्तोनस्तत्सदा)

(ग) ४. नक्षत्राणामेवं for (एवं नक्षत्राणां)

५. द्वितेन for (द्वितयेन)

२. उदयाको मस्तयकाद्यस्योनस्तत्सदादृश्यम् for (उदयाकोस्तमयाकां व्यस्तोनस्त-
 त्सदादृश्यम्)

(च) २. उदयाकोस्तमयाकां for (उदयाकोस्तमयाकां)

(क) १. त्रिभागेन for (सत्रिभागेन २. उदय (लक्षय) लग्नमधिकं कृत्वा पूर्व वदुदयास्-
 स्तार्या भवति for (उदयाकोस्तमयाकां व्यस्तोनस्तत्सदादृश्यम्)

उदयास्तसूर्योरन्तरे^१ रवौ दृश्यतेऽन्यथास्तमितः^२ ।

उनाधिकारविकला रविभुत्तया भाजिता दिवसाः ॥ ३६ ॥

षड्विंशो^१ मिथुनांशे^२ शकचत्वारिंशता ४० मृग व्याधः^३ ।

तत्क्रांतेर्दक्षिणतो^४ विक्षिप्तागस्त्यवच्छेषम् ॥ ४० ॥

गुणिता व्यासाद्धेन^५ स्वक्रान्तिज्यावलंबकहताग्रा ।

प्रतिदिनमुदयास्तमया वर्गाग्रे भग्नहमुनीनो ॥ ४१ ॥

३६. (घ) १. उदयास्तसूर्योरन्तरे (ग) उदयास्तासूर्ययो for (उदयास्तसूर्योरन्तरे)

२. स्तमित for (स्तमित) (ग) न्यथास्तमिति: for (न्यथास्तमितः)

३. उनाधिकार (ग) for (उनाधिकार)

(ग) ४. दृश्यते: for (दृश्यते)

(च) १. उदयास्तसूर्योरन्तरे for (उदयास्तसूर्योरन्तरे)

२. न्यथास्तमित for (न्यथास्तमित)

(क) ६. सूर्योरन्तर for (सूर्योरन्तरे)

४०. (घ) १. षड्विंशो (ग) (ग) for (षड्विंशो)

५. तत्क्रांतेर्दक्षिणतो (ग) तत्क्रांतेर्दक्षिणतो for (तत्क्रान्तेर्दक्षिणतो)

४. विक्षिप्तोऽगस्त्यवच्छेष (ग) विक्षिप्तोऽगस्त्यवच्छेषम् for (विक्षिप्तागस्त्य-
वच्छेषम्)

(ग) ६. मिथुनांशेऽशक for (मिथुनांशे: शक)

(च) ५. तत्क्रांते for (तत्क्रांते)

३. दक्षिणतो for (दक्षिणतो)

(क) १. विंशे for (विंशो) २. व्याधे: for (व्याधः) ३. दक्षिण for (दक्षिणतो)

४. विक्षेपोऽगस्त्य for (विक्षिप्तागस्त्य)

४१. (घ) १. ज्यावलंबकहताग्रा (ग) ज्यावलंबकोद्धृता स्वीग्रा for (ज्यावलंबकहताग्रा)

२. वर्गाग्रे (ग) for (वर्गाग्रे)

३. मुनीनाम् (ग) भग्नहमुनीनाम् (च) for (भग्नहमुनीनो)

(च) १. हताग्रा for (हताग्रा)

(क) १. प्रतिदिनमुदयास्तमयावयाग्रे वग्नहमुनीरमां

गुणिता व्यासाद्धेन स्वक्रान्तिज्या साद्धेनानेन

for (गुणिता व्यासाद्धेन स्वक्रान्तिज्या वलंबकहताग्रा । प्रतिदिनमुदयास्त-
मया वर्गाग्रे भग्नहमुनीनो ॥)

अग्राशंकुतलैवचं^१ तुल्यदिशोरन्तरं^२ तथान्यदिशो^३ ।
 प्राच्यपरायाः शंकोः तलं दग्ने^४ गूहो न च^५ ॥ ४२ ॥
 शंकुतल प्राच्यपरांतरं भुजो दक्षिणोत्तरं^६ कर्णः ।
 दग्ज्या तद्वर्गांतरमूलं दिग्मध्यतः^७ कोटिः ॥ ४३ ॥
 उनाधिकशंकुगुणाः स्वशंकुभक्ताः पृथक् स्वदग्ग्याग्रे^८ ।
 कृत्वोनाधिकशंकुदृष्टिं^९ कृत्वोनशंकुवर्गे^{१०} ॥ ४४ ॥

४२. (घ) ३. शंकोस्वलं तदग्ने for (शंकोः तलं दग्ने)
 २. भं वा (ग) for (नं च)
- (ग) ४. तथान्य दिशोः for (तथान्यदिशो)
 ५. परयोः for (परायाः)
- (ब) ६. शंको for (शंकोः)
 ३. तलं तदग्ने for (तलंदग्ने)
- (क) १. तलेकां for (तलैवचं) २. भं वा for (नं च)
४३. (घ) २. दक्षिणोत्तरः (ग) (च) for (दक्षिणोत्तरं)
 १. दग्ज्यातद्वर्गांतर मूलं (ग) (च) for (दग्ज्यावर्गान्तरमूलं)
 ३. दिग्मध्यत (च) for (दिग्मध्यतः)
- (क) ६. दुप उप स्वर्गांतर मूलं for (दग्ज्यातद्वर्गांतरमूलं)
४४. (घ) ३. ऊनाधिक (ग) (च) for (उनाधिक)
 १. दग्ग्याग्रे (ग) सुदग्ज्याग्रे for (स्वदग्ग्याग्रे)
 ४. शंक for (शंकु)
 २. शंकुवर्ग (शंकुवर्गे) (ग) शंकुवर्गे for (शंकुवर्गे)
- (ग) ५. दृश्यं for (दृष्टिं)
- (च) १. स्वदग्ग्याग्रे for (स्वदग्ग्याग्रे)
 ६. कृत्वो for (कृत्वो)
 २. शंकुवर्गे for (शंकुवर्गे)
- (क) १. दृश्या for (स्वदग्ग्याग्रे) २. शंकुः for (शंकुवर्गे)

प्रतिघटिकमधिकशंकोर्ग्रहमध्ये दर्शयेत् भुवा ।
 त्रिप्रश्नोत्तया रविवच्छंकु भ्रमणादिक्रमशेषम् ॥ ४५ ॥
 शंकु प्राच्यपरांतरं विषुवच्छायेक्य मुत्तरे नृतले ।
 याम्योत्तरं गुणहृतं स्वक्रान्तिर्लम्ब कर्णाभ्याम् ॥ ४६ ॥
 तच्चापांशा सदशः मधुवकापक्रमांशैरूना ।
 विक्षेपांशे व्यस्ता व्यस्तविशुद्धा व्यसहस्रांशैः ॥ ४७ ॥

४५. (घ) ५. मग्ने (ग) ग्रहमग्ने
 ६. दर्शयेनि (ग) दर्शयेन्मुनिं भवा for (दर्शयेत् भुवा)
 ३. रविवत्शंकु (च) for (रविवच्छंकु)
 ४. क्रमशेषम् (ग) (च) for (क्रमशेषम्)
 (ग) २. त्रिप्रश्नोक्तं for (त्रिप्रश्नोत्तया)
 (च) २. मग्ने for (मध्ये) ६. दर्शयेनि for (दर्शयेत्)
 (क) १ अधिघटिकादिसमधिशंका ग्रहणं मग्ने दर्शयन् मुनिनंद for (प्रतिघटिकमधि-
 कशंकोर्ग्रहमध्ये दर्शयेत् भुवा)
 २. तृः for (त्रि) ३. विवन् for (रविव) ४. कमा for (क्रम)
४६. (घ) २. परांतर (ग) (च) for (परांतरं)
 ३. नृतरे for (नृतले)
 १. याम्योत्तरं (ग) याम्यैरंतर for (याम्योत्तरं)
 (च) ४. मुत्तर for (मुत्तरे)
 ५. गुणहृतं for (गुणाहृतं) १. याम्योत्तरं for (याम्योत्तरं)
 (क) १. याम्योत्तरे for (याम्योत्तरं)
४७. (ट) ४. चापांशाः (ग) (च) for (चापांशा)
 १. सदशैः (ग) (च) for (सदशैः)
 ५. रूनाः (ग) for (रूना)
 ३. विक्षेपांशा (ग) विक्षेपांशाद्व्यस्ता for (विक्षेपांशे व्यस्ता)
 ६. व्यस्तविशुद्धाव्यसहस्रांशैः (ग) व्यस्तविशुद्धा for (व्यस्तविशुद्धाव्यसहस्रांशैः)
 (ग) २. मधुवका (च) for (मधुवका)
 ७. वसद्विशांशैः for (व्यसहस्रांशैः)
 (क) १. सदशै for (सदशैः) २. ध्रुवकः for (मधुवकः) ३. पांशा for (पांशे)

सहिता विक्षेपांशस्तत्क्रापांशकवशादुदयाम्या ।
 एवं विक्षेपांशाः तत्क्रांत्यंशैर्ध्रुवो रविवत् ॥ ४८ ॥
 उनेमानैक्याद्धात् गृह्योर्मध्यांतरे युतिर्ग्रहयोः ।
 समलिप्तिकयो गृहणदधिके स्फुट मानयोगाद्धात् ॥ ४९ ॥
 समलिप्तिकालिकार्कात् कृत्वा लग्नं स्वदेशराशयुदयैः ।
 गृह्योः समलिप्तिकयोः स्वदिनोदिननाडिका प्राग्वत् ॥ ५० ॥
 अधिकदिनोदितघटिकाभिरूनदिननाडिका गुणा भक्ताः ।
 अधिकदिननाडिकाभिः फलनाड्यो यदि भवन्त्यूनाः ॥ ५१ ॥

४८. (घ) ४. विक्षेपांशा (ग) for (विक्षेपांश)
 १. याम्याः (ग) (च) for (याम्या)
 ५. तत्क्रांत्यंशै (च) for (तत्क्रांत्यंशै)
 (ग) २. विक्षेपांशैस्तत्क्रान्त्यशा for (विक्षेपांशाः तत्क्रांत्यंशै)
 (क) १. यामाः for (याम्या) २. विक्षेपाश for (विक्षेपांशाः)
 ३. जातैर्विक्षेपानयनम् for (ध्रुवोरविवत्)
४९. (घ) २. ऊनेमानैक्याद्धा (ग) (च) for (उनेमानैक्याद्धात्)
 ३. ग्रहयोर्मध्यांतरे (ग) (च) for (ग्रहयोर्मध्यांतरे)
 ४. ग्रहयैः for (ग्रहयोः)
 (ग) १. ग्रहणवदधिके for (ग्रहणदधिके)
 ५. योगाद्धात् for (योगाद्धात्)
 (च) ४. ग्रहयोः for (ग्रहयोः)
 (क) १. वदधिके for (दधिके)
५०. (घ) २. राशयुदयै (ग) for (राशयुदयैः)
 १. नाडिकाः (ग) स्वदिनोदितनाडिका for (स्वदिनोदिननाडिका)
 (ग) ३. स्वदेश for (स्वदेश)
 (च) ४. कालिकार्कात् for (कालिकार्कात्)
 १. स्वदिनोदिननाडिकाः for (स्वदिनोदिननाडिका)
 ५. प्राग्वत् for (प्राग्वत्)
 (क) ६. स्वदितनाडिका for (स्वदिनोदिननाडिका) ४. कति for (कर्ति)
५१. (घ) २. नाड्यो for (नाड्यो)
 (ग) ३. भक्ता for (भक्ताः) ४. भवत्यूनम् for (भवन्त्यूनाः)
 (क) १. गुण for (दिन)

उनदिवसो^२ दिताभ्यो^३ घटिकाभ्यः प्रागथाधिकाः पश्चात् ।
 योगस्तत्^४ घटिकांतरमाद्यं^५ कृत्वेषु^६ घटिकाभिः ॥ ५२ ॥
 गुणिता^७ स्वभुक्तलिप्ता^८ षष्ठिहृताः^९ प्रागणं^{१०} धनं पश्चात् ।
 आद्यवदन्तरमन्यत्प्राक् पश्चाद्द्वान्तरं द्वितयम् ॥ ५३ ॥
 आद्यघटिकांतरं^{११} वशात्प्राक् पश्चाद् वा युतिः प्रथमकलात्^{१२} ।
 कृत्वा^{१३} पृथक्दिनोदित घटिकास्तत्कालिक ग्रहयोः ॥ ५४ ॥

५२. (घ) २. ऊन (ग) ऊनादिवसो (च) for (उनदिवसो)
 (ग) ३. प्रागधिकाः for (प्रागथाधिकाः)
 ४. कृत्वेष्ट for (कृत्वेषु)
 (च) ५. योगस्तद्धटिकांतरमाद्यं for (योगस्तत् घटिकांतरमद्यं)
 (क) १. घटिकादिफलं ग्राह्यं for (घटिकांतरमाद्यं)
 २. यदिभरमाद्यं कृत्वेष्ट for (घटिकांतरमाद्यं कृत्वेषु)
 ५३. (घ) २. गुणिताः for (गुणिता)
 ३. लिप्ता (ग) (च) for (लिप्ता)
 १. प्रागृणं (ग) (च) for (प्रागणं)
 (ग) ४. षष्ठिहृताः (च) for (षष्ठिहृताः)
 ५. पश्चाद्द्वान्तर for (पश्चाद्द्वान्तर-द्वान्तर-)
 (क) १. प्रागृण for (प्रागणं) २. गुणिताः for (गुणिता) ३. लिप्ताः for (लिप्ता) ५. पश्चाद्द्वान्तर for (पश्चाद्द्वान्तर-द्वान्तर-)
 ६. मन्यत्प्रा for (मन्यत्प्राक्)
 ५४. (घ) ३. आद्य (च) for (आद्य)
 ४. घटिकान्तरवशात् (ग) आद्यघटिकांतरवशा for (घटिकांतरं वशात्)
 ५. पृथग्दिनोदित (ग) पृथग्दिनोदित for (पृथक्दिनोदित)
 (ग) २. तात्कालिकग्रहयोः for (तत्कालिकग्रहयोः), इसकी श्लोक संख्या ५५ है ।
 (च) ४. घटिकांतरवशात् for (घटिकांतरवशात्)
 ५. पृथग्दिनोदित for (पृथक्दिनोदित)
 (क) १. कालात् for (कलात्) (ग) २. कोलिक for (कालिक) इसकी श्लोक संख्या ५५ है ।
 (ग) यद्याद्यान्यांतरयोरन्तरं हृतं मन्यथा तदैक्येन ।
 ग्राह्यन्तरादिभिर्घटिका निर्गुणित माप्ताभिः ॥ ५४ ॥
 इसमें यह अतिरिक्त श्लोक पाया गया है ।
 (क) १. आद्यंतर for (ग्राह्यंतर)

उदितघटिका यदि^१हता गुणिताश्चाद्यान्यदिवसघटिकाभिः ।
यद्याद्यानान्तरयो^३रन्तर हतमन्यथा तदैक्येन ॥ ५५ ॥

५५. (क) १. हता for (हता) २. स्वान्य for (द्यान्य)

३. अन्योदितघटिकाभिस्तुल्यो योगोभवेदसकृत् for (यद्याद्यानान्तरयो^३रन्तरहतमन्यथा तदैक्येन) इसकी श्लोक संख्या ५६ है ।

(क) यद्याद्यानान्तरयो^३रन्तर हतमन्यथा तदैक्येन ।
आद्यन्तरमिष्टाभिर्घटिकाभि गुणितामाप्ताभिः ॥ ५५ ॥

for

उदितघटिका यदि हता गुणिताश्चाद्यान्यदिवसघटिकाभिः ।
यद्याद्यानान्तरयो^३रन्तर हतमन्यथा तदैक्येन ॥ ५५ ॥

(घ) १. हता (ग) (च) for (हता)

२. गुणिताश्चश्चा (ग) गुणिताश्चस्वान्य for (गुणिताश्चाद्यान्य)

३. यद्याद्यानान्तर for (यद्याद्यानान्तरयो^३रन्तर)

वि०—इस श्लोक में एक और पंक्ति है और उसके पश्चात् क्रमसंख्या ५४ लिखी है । पंक्ति है —

“आद्यन्तरमिष्टाद्यान्तरै द्वितयं । ष्टाभिर्घटिकाभिर्गुणितामाप्ताभिः ॥ ५४ ॥
for (यद्याद्यानान्तरयो^३रन्तरहतमन्यथा तदैक्येन)

(ग) ५. उदकैत for (उदित)

वि० इसका उत्तरार्ध निम्नांकित है—श्लोक संख्या ५६ है ।

‘अन्योदितघटिकाभिस्तुल्यायोगो न चेदसकृत्’ for (यद्याद्यानान्तरयो^३रन्तर हतमन्यथा तदैक्येन)

(च) २. गुणिताश्चश्चान्यदिवसघटिकाभि for (गुणिताश्चाद्यान्यदिवसघटिकाभिः)

३. यद्याद्यानान्तर for (यद्याद्यानान्तरयो^३रन्तर)

६. हतमन्यथा for (हतमन्यथा)

आद्यं^१तरमिष्टाभिर्घटिकाभिर्गुणितमाप्ताभिः ।

अन्योदित घटिकाभिस्तुल्यो योगो भवेदसकृत् ॥ ५६ ॥

अन्येष्टनाडिकाभिः कृत्वा तुल्या यदा तदा योगः ।

कार्यो^१ अंगोन्नतिवत्^२ ग्रहमध्यान्तरे योगे ॥ ५७ ॥

५६. (क) उदितघटिका यदि हूता गुणिताश्च स्वान्यदिवस घटिकाभिः ।

अन्योदित घटिकाभिस्तुल्यो योगो भवेदसकृत् ॥ ५६ ॥

for

आद्यं^१तरमिष्टाभिर्घटिकाभिर्गुणितमाप्ताभिः ।

अन्योदित घटिकाभिस्तुल्यो योगो भवेदसकृत् ॥ ५६ ॥

(वि) इस श्लोक का पूर्वार्ध — अतिरिक्त ५४ का उत्तरार्ध भी है ।

(घ) वि० इस श्लोक की पहली पंक्ति पिछले श्लोक की अंतिम पंक्ति दर्शाई गई है ।

क्रम संख्या ५४ लिखी है ।

१. 'भिरचाद्धांतरे द्वितयं, ट्टाभिर्घटिकाभिर्गुणितमाप्ताभिः ॥ ५४ ॥' इस पंक्ति के पश्चात् ५५ संख्या कहीं नहीं है । हां "अन्योदित असकृत्" लिखकर ॥ ५६ ॥ संख्या लिखदी है ।

(ग) यह श्लोक इस प्रति में नहीं है ।

इसकी पहली पंक्ति—ग के ५४ संख्यावाले श्लोक की दूसरी पंक्ति है । तथा ग के ५६ संख्या वाले श्लोक की दूसरी पंक्ति, इसकी दूसरी पंक्ति है । देखो पिछला श्लोक ।

(च) २. यहां पर भी क्रमसंख्या ५६ दी हुई है ।

५७. (घ) २. शृंगोन्नतिवद्ग्रहमध्यान्तरे (ग) शृंगोन्नतिवद्ग्रहयो for (अंगोन्नतिवत् ग्रह-मध्यान्तरे)

१. कार्यो for (कार्यो)

३. मध्यान्तरे for (मध्यान्तरे)

इसकी श्लोक संख्या मिलती जुलती है ।

(च) ४. कृत्वा for (कृत्वा) शृंगोन्नतिवद्ग्रहमध्यान्तरे योगे for (अंगोन्नतिवत् ग्रहमध्यान्तरे योगे)

(क) १. कार्यो for (कार्यो) २. शृङ्गान्नति for (अंगोन्नति)

३. ग्रहयोम् for (ग्रहमध्यान्तरे) ४. योगः for (योगे)

बाहु^५ संयोगांतरमन्नाश^१क्वग्रयोः^१ सामान्यदिशोः^२ ।

कर्णोदग्ज्येकोटि^३ स्वकर्णभुजकृतिविशेषपदे ॥ ५८ ॥

कोटिभुजकर्णशंकु^४ षष्टि^५ गुणाध्वाहता^६ मध्यात् ।

कोटि प्रथक्चसार्ये प्राच्यां प्रागपरयोः पश्चात् ॥ ५९ ॥

५८. (घ) १. माग्रो शंकुग्राह्याः (ग) मग्राशंकवग्रयो for (मन्नाशंकवग्रयोः)

२. सामान्यदिशोः for (सम्मान्यदिशोः)

३. दृज्येकोटि (ग) कर्णो दृज्येकोटी for (कर्णोदग्ज्येकोटि)

४. विशेषपदे for विशेषपदे)

(ग) ५. बाहुः for (बाहु)

(च) १. माग्राशंकुग्राह्योः for (मन्नाशंकवग्रयोः)

२. सामान्यदिशोः for सामान्यदिशोः)

३. दृज्येकोटी for (कोटि) ४. विशेषपदे for (विशेषपदे)

(क) १. मग्रासंक्ल for (मन्नाशंकवग्रयोः) २. दृश्यौ for (दिशोः) ३. कौटी for (कोटि)

५९. (घ) ३. गुणाध्वाहता हतान्मध्यात् (ग) गुणान् व्यासदलहतान् for (गुणाध्वाहता मध्यात्)

३. कोटी पृथक् पृथार्ये (ग) कोटीपृथक् प्रसार्ये for (कोटि प्रथक्चसार्ये)

(ग) ६. शंकून् for (शंकु)

७. प्रागपरयाः for (प्रागपरयोः)

(च) ३. गुणा ध्वाहतामध्यात् for (गुणाध्वाहतामध्यात्)

४. कोटी for (कोटि)

८. पृथक्पृथार्ये for (प्रथक्चसार्ये)

(क) १. काटिभुजर्ण for (कोटि भुजकर्णं) २. षष्टि (ग) for (षष्टि)

३. गुणात् व्यासितात्म for (गुणाध्वाहता मध्यात्)

४. क्वाऽप्रपृथक् प्रसार्ये for (कोटिप्रथक्चसार्ये) ५. मध्यात् for (पश्चात्)

कोट्यग्राम्यां बाहुकर्णो दिग्मध्यतो भुजाग्रांतौ ।
 बाहुग्राह्यो स्वशंकुषष्टि मध्यान्तराग्रांते ॥ ६० ॥
 दिग्मध्ये स्थित द्रष्टृया पृथग् ग्रहौ दर्शयेत् स्वशंकुवप्रे ।
 योगे शंकुवग्नन्तरमन्तरमथवान्यदाग्रहयोः ॥ ६१ ॥
 नाचार्यो ज्ञातेरपि तन्त्रैरार्यभटविष्णुचन्द्राद्यैः ।
 यो ब्रह्मधूलिकर्म विदाचार्यत्वं भवति तस्य ॥ ६२ ॥

६०. (घ) ४. ग्राह्या for (ग्राह्यो) (ग) बाहुग्रयोः for (बाहुग्राह्यो)
 ५. शंकुयष्टी (ग) for (शंकुषष्टि)
 (ग) १. कर्णो for (कर्णो)
 ६. मध्यात्तदाग्रांते for (मध्यान्तराग्रांते)
 (च) ७. कोट्यग्राम्यां for (कोट्यग्राम्यां) बाहुकर्णो for (बाहुकर्णो)
 ३. भुजाग्रांतौ for (भुजाग्रांतौ)
 ४. बाहुग्राह्यो for (बाहुग्राह्यो) ५. स्वशंकुयष्टी for (शंकुषष्टि)
 ६. मध्यान्तराग्रांते for (मध्यान्तराग्रांते)
 (क) १. कणात् for (कर्णो) २. द्वग् for (दिग्) ३. भुजाग्रांतौ for (भुजाग्रांतौ)
 ४. बाहुग्रयोः for (बाहुग्राह्यो) ५. यष्टि for (षष्टि)
 ६. मध्यत्तदग्रते for (मध्यान्तराग्रांते)
६१. (घ) १. द्रष्टृया (ग) (च) for (द्रष्टृया)
 ३. शंकुवग्रांतर (ग) शंकुवग्रांतर for (शंकुवग्रांतर)
 (ग) ४. दिग्मध्यस्थित for (दिग्मध्येस्थित)
 (च) ३. शंकुवग्रांतर for (शंकुवग्नन्तर)
 (क) १. द्रष्टृया for (द्रष्टृया) २. ग्रहोदशयज्ञ for (ग्रहौ दर्शयेत्)
 ३. स्वस्वाप्रतिर्मततो सलम्य for (शंकुवग्नन्तरमन्तर)
६२. (घ) १. न वार्यो (ग) नाचार्यो for (नाचार्यो)
 २. ज्ञातेरपि (ग) (च) for (ज्ञातेरपि)
 ३. ब्राह्मधूलि (च) ब्राह्मधूलिकर्म for (ब्रह्मधूलिकर्म)
 (ग) ४. राचार्यभट for (रार्यभट)
 (क) १. नाचार्यो for (नाचार्यो) २. जातै for (ज्ञातेरपि) ३. ब्राह्म for (ब्रह्म)

रविशशितमस्त्रिवरितं ब्रह्मोक्तं पुण्यमद्भुतं ज्ञात्वा ।
 रविचन्द्रराहु लोकात् प्राप्नोति पुमानिह यशश्च ॥ ६३ ॥
 अन्यैरप्युक्तमिदं योयं सम्यक् ग्रहं विजानाति ।
 याति सदरलोकं ग्रहाष्टकज्ञं परं ब्रह्मा ॥ ६४ ॥
 मध्यमगतिः स्फुटगतिः स्त्रिप्रश्नश्चन्द्रभास्कर ग्रहणौ ।
 उदयास्तमयप्रतिघटिकाभिदोः शृङ्गोन्नतिछाये ॥ ६५ ॥

६३. (घ) १. तृवरितं (ग) तमस्त्रिचरितं for (तमस्त्रिवरितं)
 ३. पुमानिह (च) for (पुमानिह)
 (ग) ४. श्रुत्वा for (ज्ञात्वा)
 २. लोकान् for (लोकात्)
 (च) १. तमसृचरितं for (तमस्त्रिचरितं)
 (क) १. चरितं for (वरितं) २. लोकान् (ग) for (लोकात्)
 ३. पुमानिह (ग) for (पुमानिह)
६४. (घ) ४. अन्यैरप्युक्तमिदं (ग) (च) for (अन्यैरप्युक्तमिदं)
 ५. सम्य (ग) सम्यग्रहं for (सम्यक्ग्रहं)
 २. सतद्ग्रहलोकं (ग) (च) for (सदरलोकं)
 ३. ग्रहाष्टज्ञः (ग) ग्रहाष्टकज्ञः for (ग्रहाष्टकज्ञं)
 (ग) ४. ब्रह्माः for (ब्रह्मा)
 (च) ५. सम्यग्रहं for (सम्यक्ग्रहं)
 ३. ग्रहाष्टकज्ञः for (ग्रहाष्टकज्ञं)
 (क) २. सतग्रह for (सदरलोकं)
 ३. ग्रहाष्टज्ञः for (ग्रहाष्टकज्ञं)
६५. (घ) १. भास्करं (च) for (भास्कर)
 २. उदयास्तमयः (ग) उदयास्तमयौ for (उदयास्तमय)
 ३. प्रतिघटिकान्मिदो (ग) प्रतिघटिकामिदु for (प्रतिघटिकाभिदोः)
 (ग) ४. मध्यगतिः for (मध्यमगतिः)
 ५. स्पष्टगति for (स्फुटगति) ६. त्रिप्रश्नचन्द्र for (त्रिप्रश्नश्चन्द्र)
 (च) २. उदयास्तमयः for (उदयास्तमय) ३. प्रतिघटिकामिदो for (प्रतिघटिकाभिदोः)
 (क) १. मध्यमगतिस्त्रिप्रश्नश्चन्द्र भास्कर ग्रहणौ । उदयास्तमयः । चन्द्रग्रहणं चतुर्थः
 सूर्यग्रहणं पञ्चमः । उदयास्तमय षष्ठाप्रति घटिका मिदोः शृङ्गोन्नति छाये ।
 for (मध्यमगतिः स्फुटगतिस्त्रिप्रश्नश्चन्द्रभास्करग्रहणौ । उदयास्तमय प्रतिघ-
 टिकामिदोः शृङ्गोन्नतिछाये ।)

ग्रहयोगोत्रं ग्रहयुतिरार्यात्रिशति युताष्ट सप्तत्या ३७८
 अध्यायेदंशभिर्धूर्लिकर्म वोच्चैर्विना ब्रह्म ॥ ६६ ॥
 गुरुणा नष्टलिकर्म प्रतिकंचुककारिणे प्रदातव्यम् ।
 दत्तं सुकृत्प्रणाशं कुरुते प्रतिकंचुकं यस्य ॥ ६७ ॥
 ग्रहमेलके यदुक्तं तत्स्थूलं स्पष्टमिह यदुक्तं तत् ।
 ग्रहभमुनीदु छाया शृङ्गोन्नतिभोदयाद्येषु ॥ ६८ ॥
 सूर्यास्तमयादिष्टाद्रातिगताद्येष्ट भोदयास्तमयौ ।
 जानाति न कश्चिदपि ब्राह्मणं मुच्यते न्यतन्भजः ॥ ६९ ॥

६६. (घ) १. भ (ग) (च) for (त्र)

(ग) ३. त्रिशती for (त्रिशति)

४. चाद्यै for (वोच्चै)

(च) ५. दंशभि for (दशभि)

६. धूर्लिकर्म for (धूर्लिकर्म)

(क) १. भ for (त्र)

२. ब्राह्मी (ग) ब्राह्म्ये for (ब्रह्म)

६७. (घ) ३. योस्य (ग) (च) for (यस्य)

(ग) १. प्रतिकंचककारिणे for (प्रतिकंचुककारिणे)

४. सुकृतः प्रणाशः for (सुकृत्प्रणाशः)

(च) ५. कर्म for (कर्म)

(क) १. प्रातस्यर्कं कारिणे for (प्रतिकंचुककारिणे)

२. सुर्कं योस्या for (चुकं यस्य)

६८. (घ) १. ग्रहभमुनीदु (ग) for (ग्रहभमुनीदु)

(ग) ३. स्पष्टमिदं for (स्पष्टमिह)

(च) ५. तस्थूलं for (तत्स्थूलं)

(क) १. ग्रहण मनीदुछायो for (ग्रहभमुनीदुछाया) २. लोदयाद्येषु for (भोदयाद्येषु)

४. ग्रहामेलके for (ग्रहमेलके)

३. स्पष्ट इह for (स्पष्टमिह)

यह यहीं समाप्त है ।

६९. (घ) १. दिष्ट्याद्ग्रातिगता for (दिष्टाद्रातिगता) (ग) सूर्यास्तमयाद्वारातिगता for (सूर्यास्तमयादिष्टाद्रातिगता)

२. द्वेष्ट (ग) स्वेष्टभोदयास्तमयोः for (द्वेष्टभोदयास्तमयौ)

३. ब्राह्मं मुच्यते न्यतन्भजः (ग) ब्राह्मं मुक्तान्यतन्भजः for (ब्राह्मणं मुच्यते न्यतन्भजः)

(क) यह श्लोक उपलब्ध नहीं,

(च) १. दिष्ट्याद्ग्रातिगता for (दिष्टाद्रातिगता) २. द्वेष्ट for (द्वेष्ट)

३. ब्राह्मं मुच्यते न्यतन्भजः for (ब्राह्मणं मुच्यते न्यतन्भजः)

भमुनीध्रुव विक्षेप गृहोदयास्त मयनाडिकाद्येषु ।

अध्यायोभग्रह युतिरार्याणां सप्तति दंश ॥ ७० ॥

इति ब्रह्मगुप्ते दशमोऽध्यायः ॥

इति श्री ब्राह्मस्फुटसिद्धान्ते ग्रहतारादिक्षेपाधिकारोदशमः ॥ १० ॥

सम्पूर्णा पूर्वादशाध्यायी

७०. (घ) १. भमुनि (ग) (च) for (भगु)

२. दंशमा for (दंश)

(ग) ३. कालिकाद्येषु for (नाडिकाद्येषु)

आर्याणां सप्तत्या दशमोभग्रहयुतिरध्यायः ॥ ७० ॥

इति श्री ब्रह्मगुप्ताचार्य विरचिता दशाध्यायी समाप्ता ॥

for (अध्यायोभग्रहयुतिरार्याणां सप्ततिदंश ॥७०॥ इति ब्रह्मगुप्ते दशमोऽध्यायः)

(क) यह श्लोक उपलब्ध नहीं है ।

(च) २. दंश for (दंश)

४. 'इति' से 'अध्यायः' तक लुप्त

(ग) वि०-अतिरिक्त पाठ—

इति श्री ब्रह्मगुप्ताचार्य विरचिता दशाध्यायी समाप्ता । अथ स्वस्ति श्री संवत् १६७७ वर्षे शाके १५४३ प्रवर्तमाने ॥ ज्येष्ठबदि १० सोमे । रेवती घटी १८ पल १७ नक्षत्रे । अत्र ग्रन्थ लिखित समये श्री राजनगर मध्यवा-स्तव्यं । श्री.....जातीय । ज्योति श्री ...कस्य इयं पुस्तिकालिखितमस्ति । उक्तं च । यादृशं पुस्के द्रिष्ट्वा तादृशं लिखितं मया । यदिशुद्धम-शुद्धं वा मम दोषो न दीयते ॥ पुनः ॥ भगवदृष्टि कटिग्रीवाबद्धमुष्टिरधोमुखम् । कष्टेन लिखितं शास्त्रं यत्नेन परिपालयेत् । लेखकपाटकयोः शुभं भवतु । स्वयं पठनार्थं तथापुत्रपौत्रादिपठनार्थं । परोपकारार्थं । श्री कृष्णार्पणमस्तु ॥ श्रीरस्तु मंगल मस्तु । शुभंभवतु । जयोस्तु । छः छः छः छः छः छः । उक्तं च । ब्रह्मा प्राह त नारदाय हिमगुर्यं शौनकायालं मांडव्याय वसिष्ठसंज्ञकमुनिः सूर्या-मियायं हि यत् । सत्पक्षागमशास्त्र युक्तमभिदं शास्त्रं विहायान्यथा । ये कुर्वन्ति नरान् निर्वहन्ति तौ विज्ञानशून्याश्चिरम् ॥

अथ तन्त्र परीक्षा नामैकादशोऽध्यायः

ये^१ ज्ञान पटलरूढदशो^२न्यब्रह्मा^३द्वदन्ति सिद्धान्तम्^४ ।
 तेषां युगादिभेदे^५ दोषास्तान्प्रवक्ष्यामि ॥ १ ॥
 युगमाहुः पञ्चाब्दं^१ रविशशिनोः^२ संहितां^३ कारये ।
 अधिमासा वमरात्र स्फुटतिथ्यज्ञान तदसत् ॥ २ ॥

१. (घ) १. येऽज्ञान for (ये ज्ञान)

२. रूढदशो (ग) रूढदशो for (रूढदशो)

३. न्यद्ब्राह्माद्वदन्ति (ग) न्यद्ब्राह्माद्वदन्ति for (न्यद्ब्राह्माद्वदन्ति)

४. सिद्धांतात् (ग) (च) for (सिद्धान्तम्)

५. भेदाद्ये (ग) (च) for (भेदेद्ये)

६. प्रवक्ष्यामि (ग) प्रवक्ष्यामि for (प्रवक्ष्यामि)

(च) २. रूढदशो for (रूढदशो)

३. ब्राह्माद्वदन्ति for (ब्रह्माद्वदन्ति) ४. सिद्धान्तात् for (सिद्धान्तम्)

६. प्रवक्ष्यामि for (प्रवक्ष्यामि)

(ग) वि०-अतिरिक्त पाठ—

अथ ब्रह्मगुप्तसिद्धांते एकादशमोऽध्यायः प्रारभ्यते ॥ खखखार्क १२०००
 द्रवृतान्देभ्यो गतगम्याल्पा-त्खसून्य यमल । २०० हतात् । लब्धं त्रि ३
 सायक हतं कलाभिरूनौ सदाकंदू ॥ १ ॥ विधु वज्जीवेद्वि २ हतं चन्द्रोच्चे
 तिथि १५ गुरां च सितशीघ्रे ॥ द्वीषु ५२ हतं च स्वार् द्वि २ कु १ वेद
 ४ हतं च पात कुजशनिषु ॥ २ ॥ ग्रहबीजानि ब्रह्मसिद्धांते ॥

२. (घ) १. पंचाक्षरं for (पञ्चाब्दं)

२. ज्ञानतस्तदसत् (ग) तस्तदसत् for (ज्ञानतदसत्)

(ग) ३. —रयै for (कारये)

४. स्फुटिथ्य for (स्फुटतिथ्य)

५. ज्ञान् for (ज्ञान)

(च) ३. काराय for (कारये)

भानि ध्रुवपंचाशत् द्वावर्कादयो जिनोक्तं यत् ।
 ध्रुवमसस्यावर्णो भवति यतोह्ना ततो सत्तत् ॥ ३ ॥
 आर्यभटो युगपादास्त्रीन् पातानाह कलियुगादौ यत् ।
 ३२४०००० तस्य कृतां तर्ह्यस्मात् स्वयुगाद्यंतौ न तस्मात् ॥ ४ ॥
 रवियुगभगणां रव्युधृति ४३२०००० यत्प्रोक्तं तत्रयोर्युगं स्पष्टम् ।
 त्रिशतीरव्युदयानां तदन्तरं हेतुना केन ॥ ५ ॥

३. (घ) १. पंचाशत् for (पंचाशत्) (ग) चतुः पंचाशत् द्वौ for (ध्रुवपंचाशत् द्वा)
 २. ध्रुवमत्सस्या (ग) ध्रुवमत्सस्यावर्णो for (ध्रुवमसस्यावर्णो)
 ३. यतोह्ना ततोसत्तत् (ग) for (यतोह्नाततो सत्तत्)

- (च) ४. द्वावर्कादयो for (द्वावर्कादयो)
 २. ध्रुवमत्सस्यावर्णो for (ध्रुवमसस्यावर्णो)
 ३. यतोह्ना ततो सत्तत् for (यतोह्ना ततो स तत्)

४. (घ) १. अर्यभटो for (आर्यभटो) (ग) आर्यभटोसुत for (आर्यभटोयुग)
 २. यस्मात्तं for (यस्मात् स्व)
 ३. तत्तस्मात् (ग) for (न तस्मात्)

- (ग) ४. यतोनाह for (पातानाह)

- (च) १. अर्यभटो for (आर्यभटो)
 ३. न तत्तस्मात् for (न तस्मात्)

५. (घ) १. ४३२००० (च) for (४३२००००)
 २. तत्रयो for (तत्रयो)
 ३. स्पष्टान्यत् for (स्पष्टम्)

वि०—इस श्लोक की दूसरी पंक्ति यहां लिपिकार लिखना भूल गया प्रतीत होता है। यही नहीं छोड़े श्लोक की पहली पंक्ति भी यहां लुप्त है।

- (ग) ४. युगरविभगणाः for (रवियुगभगणाः)
 ५. रव्युधृति for (रव्युधृति)
 ६. युगं for (युगं)
 ७. + ३०० ॥०॥ +

- (च) १. ४३२०० यत्प्रोक्तं for (४३२००००

युगवर्षा^१दिनवदच्चैत्र^२ सितादेः समं प्रवृत्तान्यत् ।
 तदसत् यतः स्फुटयुगं^३ तत्स्थैर्यान्मंदपातानाम् ॥ ६ ॥
 ग्रहभुक्त^४रूनाया मंदोच्चं भवति शीघ्रमधिकायाम् ।
 उच्चगतौ मंदोच्चं न विना भुक्त^५दु वज्रमेतः ॥ ७ ॥
 आर्याष्टशते पाता भ्रमन्ति दशगीतके स्थिराः पठिताः ।
 मुक्त^६दुपातमंडपमण्डले भ्रमन्ति स्थिरानातः ॥ ८ ॥
 आर्यभटो जानाति ग्रहाष्टाति^७ यदुक्तवांस्तदसत् ।
 राहुकृतं न ग्रहणं तत्पातो नाष्टमो राहुः ॥ ९ ॥

६. (घ) यहां श्लोक का पूर्वार्ध लुप्त है ।

१. तदराज् (ग) तदसद्युतः for (तदसत्—तदसत् यतः)

२. तत्स्थैर्यान् (ग) स्थैर्यान् for (तत्स्थैर्यान्)

(ग) ३. युगवर्षादी for (युगवर्षादि)

४. सप्रवृत्तान्यत् for (समं प्रवृत्तान्यत्)

५. युतं गं न for (युगं)

७. (घ) १. रूनायां for (रूनाया)

२. भुक्तचेन्दु for (भुक्तेन्दु)

३. वर्जमतः for (वर्जमेतः)

(ग) ४. परिधि फले व्यावहारिके त्रिगुणे for (मंदोच्चं भवति शीघ्रमधिकायाम्)

५. दूसरी पंक्ति बिल्कुल भिन्न है—

‘तद्वर्ग्यां दशभिः संगुणिताभ्यां सूक्ष्मे’

वि०—तीसरी पंक्ति यह है—

उच्चं भवति शीघ्रमधिकायां । उच्चगतौ मंदोच्चं न विना भुक्तयेदुवर्जमनः ॥७॥

अर्थात् रेखांकित दो पंक्तियां अधिक हैं ।

८. (घ) १. आर्याष्टशते (च) for (आर्याष्टशते)

२. दशगीतके (ग) दशगीतिके for (दशगीतके)

३. मुक्तवेन्दु (ग) for (मुक्तेन्दु)

४. भ्रमन्ति (ग) for (भ्रमति)

(ग) ५. मपमण्डले for (मंडपमण्डले) (च)

(च) २. दशगीतके for (दशगीतिके)

९. (घ) १. ग्रहाष्टकगति (ग) for (ग्रहाष्टाति)

२. तत्पातो (ग) तस्यातो for (तत्पातो)

न^३ समायुगमनुकल्पाः कल्पादिगत^१ कृतादियातं च ।
 स्मृत्युक्तै^२ रायभटो ना तो जानाति मध्यगतिं ॥ १० ॥
 उँकारो^३ दिनवारो गुरुरदयिकोस्य भवति कल्पादौ ।
 न भवत्यर्को यस्मादोँकारे विस्वरस्तस्मात् ॥ ११ ॥
 सूर्योदयाच्चतुर्थात्^४ दिनपात् यदुवाच तदसदार्यभटः ।
 लंकोदयो यतोर्क^५ स्यास्तमयं प्राह सिद्ध पुरे ॥ १२ ॥
 आधिकैः^१ शतैश्चतुर्भिर्वर्ष^२ सहस्रैश्चतुर्दशाभिरेकः १४४०० ।
 युगपातै^३ दिनवारोत्तरयोदयिकद्वं^४ रात्रिकयोः ॥ १३ ॥

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१०. (घ) १. कल्पादिगतं (ग) (च) for (कल्पादिगत)
 २. स्मृत्युक्तै^२ रायभटो for (स्मृत्युक्तै^२ रायभटो)
 (ग) ३. समायुतं गमनुकल्पाः for (समायुगमनुकल्पाः)
११. (घ) १. ओँकारो for (उँकारो)
 २. रौदयिको (ग) रौदयिकयेस्य for (रदयिकोस्य)
 (ग) ३. दिनचरै for (दिनवारो)
 (च) २. गुरुरौदयिको for (गुरुरदयिको)
 ४. न भवत्यर्को for (न भवत्यर्को)
१२. (ग) १. चतुर्थान् for (चतुर्थात्)
 २. दिनपान for (दिनपात्)
 ३. तव for (तद)
 ४. लंकोदये for (लंकोदयो)
 ५. यतोर्क^५ स्या for (यतोर्कस्या)
१३. (घ) १. अधिकैः (ग) (च) for (आधिकैः)
 २. चतुर्भिर्वर्ष (ग) (च) for (चतुर्भिर्वर्ष)
 ३. चतुर्दशाभिरेकः (ग) (च) for (चतुर्दशाभिरेकः)
 ४. मोदयिकद्वं (ग) for (योदयिकद्वं)
 (ग) ५. युगजातै for (युगपातै)
 ६. दिनवारोत्तर for (दिनवारोत्तर)
 (च) ४. मोदयिकद्वं for (योदयिकद्वं)

उदयिकादिन^१ भुत्त^२चाद्ध^३रात्रिको मध्यमोभवेत्^४पूतः ।
 कतरं^५ स्फुटं न निश्चितमनयोः स्फुटमेकमपि नातः ॥ १४ ॥
 षोडशगियिवि^१ योजन परिधिं^२ षड्भूव्यासं^३ पुनर्लावदता ।
 आत्मज्ञानं^४ व्यापितमनिश्चयः स्वमतिकृतकत्वात् ॥ १५ ॥
 भूव्यासस्य^१ ज्ञाना^२ ष्व्यर्थं देशांतरं^३ दज्ञानात् ।
 स्फुटतिथ्यन्ताज्ञानं^४ तिथिनाशाद् ग्रहणयोनाशः ॥ १६ ॥

१४. (घ) १. औदयिकादिन (ग) औदयिकादिन for (उदयिकादिन)

२. भुत्तचाद्ध for (भुत्तचाद्ध)

३. भवेत्पूतः (ग) (च) for (भवेत्पूतः)

४. कतरत् (ग) कतर for (कतरं)

५. निश्चित for (निश्चित) (च)

(ग) ६. मतिनातः for (मपिनातः)

(च) १. औदयिकादिन for (उदयिकादिन) ४. कतरत् for (कतरं)

१५. (घ) १. षोडशगियियोजनपरिधिं (ग) षोडासगियियोजनपरिधिं for (षोडशगियिवि-
 योजन परिधिं)

२. षडि भूव्यासं (ग) निभूव्यासं for (षड्भूव्यासं)

३. पुनर्जिलावदता (ग) पुना लावदता for (पुनर्लावदता)

४. आत्माज्ञानं (ग) (च) for (आत्मज्ञानं)

(च) २. षड्भिभूव्यासं for (षड्भूव्यासं)

३. पुनर्जिलावदता for (पुनर्लावदता)

४. यहाँ क्रमसंस्था लुप्त है ।

१६. (घ) १. भूव्यासस्या (ग) (च) for (भूव्यासस्य)

२. ज्ञानाद्व्यर्थं (ग) (च) for (ज्ञानाद्व्यर्थं)

३. तदज्ञानात् (ग) for (दज्ञानात्)

४. ज्ञानम् (ग) for (ज्ञान)

५. नाशादग्रहणयोनाशः (ग) for (नाशादग्रहणयो नाशः)

(च) ५. नाशादग्रहणयोनाशः for (नाशादग्रहणयो नाशः)

प्रागेनैतिकलाभूर्यदि तत्कुतो व्रजेतिकमध्यानम् ।
 आर्वतनमुर्व्याश्चेत् पतंति समुद्धयः कस्मात् ॥ १७ ॥
 उदयिके यः परिधिविषमोन्योन्य समेन्यभुजस्य गुणः ।
 तदसद्विषमांतफलं यतोऽन्ययुग्मादि फल तुल्यम् ॥ १८ ॥
 विषमोन्योन्ये युग्मे परिधिगुणकः क्रमोक्रमाद्यानाम् ।
 चक्राद्धं फलनाशो न भवति यस्मादसत्तदपि ॥ १९ ॥
 व्यासार्द्धहतो बाहुः परिधिविशेषाहतः फलोनयुतः ।
 प्रथमोधिकोनकोय तदसत्पदयोः परिधिपाठात् ॥ २० ॥

१७. (घ) १. कलां (ग) (च) for (कला)
 २. तत्कुतो (ग) तत्क्व कुतो (तत्कुतो)
 ३. चेन्न for (चेत्त)
 ४. समुद्धयः (ग) समुद्धयाः for (समुद्धयः)
 (ग) ५. भूर्यदि for (भूर्यदि)
 ६. आर्वतनमुर्व्याश्चेत्त (च) for (आर्वतनमुर्व्याश्चेत्त)
 (च) ४. समुद्धयः for (समुद्धयः) २. तत्क्वकुतो for (तत्कुतो)
१८. (घ) १. औदयिके (ग) (च) for (उदयिके)
 २. द्विषमेन्योन्य (ग) विषमेन्योन्यः for (विषमोन्योन्य)
 ३. समे भुजस्य गुणः (ग) समे भुजस्य गुणाः for (समेन्यभुजस्य गुणः)
 ४. युग्मादि for (युग्मादि)
 (ग) ५. यतोऽन्य for (यतोऽन्य)
 (च) २. द्विविषमे for (विषमो) ३. समे भुजस्य for (समेन्यभुजस्य)
१९. (घ) १. विषमे (ग) (च) for (विषमो) २. न्यो (ग) for (न्योन्ये)
 ३. क्रमोत्क्रमाद्यानाम् (ग) for (क्रमोक्रमाद्यानाम्)
 (च) १. विषमेन्योन्ययुग्मे for (विषमोन्यान्ये युग्मे)
 ३. क्रमोत्क्रमाद्यानां for (क्रमोक्रमाद्यानां)
२०. (घ) १. कोयत्तदसत् for (कोयत्तदसत्) (ग) २. हतो for (हतो)
 (च) २. हतो for (हतो) १. यत्तदसत्पदयोः for (यत्तदसत्पदयोः)

विषमसमयोर्यदि द्वौ परिधि किं सूर्य चन्द्रयोनोक्तौ ।
 घटते न कथंचिदियं स्फुटक्रियोदयिकतन्त्रोक्ता ॥ २१ ॥
 उत्तरगोले ग्रायां विषुवद्यातो यदुक्तमुनायाम् ।
 सममंडलगस्तदसत् क्रान्तिज्यायां यतो भवति ॥ २२ ॥
 व्यासाद्धेन भविभक्ता दग्गतिजीवा चतुर्गुणा लब्धम् ।
 लंबननाड्यः पंचदशगुणितया त्रिज्यया भक्ताः ॥ २३ ॥
 दक्षेपज्या भुक्तितराहता लब्धमवनतिर्भवति ।
 स्फुटयोजनकर्णान्यां भूव्यासाद्धेन च विना स्पष्टे ॥ २४ ॥
 आर्यभटेनास्मि सतिलघुनि किमर्थं महत्कृतं कर्म ।
 गणिताज्ञानाजाड्यं विज्ञानयता यदि ततः सुतराम् ॥ २५ ॥

२१. (घ) १. परिधी (ग) (च) for (परिधि)
 २. योनोक्तौ (ग) योनोक्तौ for (योनोक्तौ)
२२. (घ) १. मूनायाम् (ग) (च) for (मुनायाम्)
 (ग) २. गोखे for (गोले)
 ३. ज्यातो for (द्यातो)
२३. (घ) १. ताड्यः for (नाड्यः) २. दग्गति (ग) दगाति for (दग्गति)
 (ग) ३. 'भ' लुप्त है ।
 ४. चतुर्गुणा for (चतुर्गुणा)
 ५. भक्ता for (भक्ताः)
 (च) २. दग्गति for (दग्गति)
२४. (घ) १. तराद्धिता for (तराहता)
 (ग) २. भुक्तचंतरा for (भुक्तितरा)
 ३. भूव्यासे for (भूव्यासाद्धेन)
 (च) १. हता for (हता)
२५. (घ) १. आर्यभटेनास्मि सति (ग) आर्यभटेनास्मि न सति for (आर्यभटेनास्मिमति)
 २. कर्मः for (कर्म)
 ३. ज्जाड्य' for (जाड्य')
 (ग) ४. लघुति for (लघुनि)
 ५. ज्ञातानाज्जाड्य' for (ज्ञानाजाड्य')
 ६. विज्ञानता for (विज्ञानयता)
 (च) २. कर्म for (कर्म)

लंबनमृणधनमुक्तं पूर्वापरयोस्तिथौ दिनाद्धं स्य ।
 युक्तो भावो यद्भवति तदृणधनयोस्थिकधरम् ॥ २६ ॥
 दृक्षेपज्या बाहु दृज्याकर्णोनयोः क्तितिशेषात् ।
 मूलदृगतिजीवा संस्थानमयुक्तमेतदपि ॥ २७ ॥
 लंबनघटिका लिप्ता दृशज्ययाकेंदुदृगगतिकलानाम् ।
 यस्मान्न समस्तस्मात् दृशज्यया लंबनं स्थूलम् ॥ २८ ॥
 वित्रिभलग्ने दृक्षेपमंडलयुतो ज्या मध्या ।
 मध्यादृक्षे पज्यानार्यभटोक्तनया तुल्या ॥ २९ ॥

२६. (घ) १. स्थितौ (ग) for (स्तिथौ)
 २. कतरत् (ग) for (कधरम्)
 (ग) ३. पूर्वापरस्थितौ for (पूर्वापरयोस्तिथौ)
 (च) १. स्तिथोकतरत् for (स्थिकधरम्)
२७. (घ) १. दृक्षेपज्या (ग) क्षेपज्या for (दृक्षेपज्या)
 २. कृतिविशेषात् for (क्तितिशेषात्)
 (ग) ३. दृगत्या for (दृज्या)
 २. कृतिविशेषात् (च) for (क्तितिशेषात्)
 (च) १. दृक्षेपज्या for (दृक्षेपज्या) ५. दृग्या for (दृज्या)
२८. (घ) १. दश (ग) दश for (दृश)
 २. समा (च) for (सम)
 (ग) ३. यस्मा समास्तस्मा for (यस्मान्न)
 (च) १. दशज्ययाकेंदु for (दृशज्ययाकेंदु)
 ४. दृगति for (दृगति) ५. दशज्यया for (दृशज्यया)
२९. (घ) १. मंडलं तदप (ग) मंडलं तप तदप for (मंडल युतो)
 २. युतौ (ग) for (युतो)
 ३. (लुप्त)
 ४. भटोक्ततया (ग) for (भटोक्तनया)
 (च) ३. "मध्या" लुप्त ५. दृक्षेपज्या for (दृक्षेपज्या)
 ४. भटोक्त तया for (भटोक्तनया)

दृक्षेपज्यातो सत्तन्नाशादवनते भवति ।
 नाशः ^१अवनतिनाशा^२भ्रामस्थो ^३नाधिकवार विग्रहणो ॥ ३० ॥
 पंचज्यया यतोर्कं^४ग्रहणं श्रीषेणविष्णुचन्द्रकृतम् ।
 आर्यभटोक्तान्यनयोर्कं ग्रह दुषणानि ततः ॥ ३१ ॥
 एवं विचार्यमाणं पंचज्यालम्बनं महास्थूलम् ।
 स्थूलावनतिश्च तथा दृशज्यया लंबनावनति ॥ ३२ ॥
 नाडीचतुष्टुविधिना सर्वत्रसमो यतस्तत स्थूलः ।
 मानार्थकर्ममहकृत् मार्यभटेन लघुनि सति ॥ ३३ ॥

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३०. (घ) १. पहली पंक्ति का अंतिम शब्द 'नाशः' ।
 २. नाशाद्भासस्थो for (नाशाभ्रामस्थो)
 ३. नाधिकता रवि for (नाधिकवारवि)
 (ग) ४. भवति नाशः for (भवति)
 ५. दूसरी पंक्ति का आरम्भ 'अवनतिनाशाद्भासस्थो ना'
 (च) २. नाशाद्भासस्थो for (नाशाभ्रामस्थो)
३१. (घ) १. विष्णु चं कृतं for (विष्णुचन्द्रकृतम्)
 २. दुषणानि (ग) for (दुषणानि)
 (च) ३. यतोर्कं for (यतोर्कं) १. चन्द्रकृतं for (चन्द्रकृतम्)
 ४. रर्कं for (रर्कं)
३२. (घ) १. स्थूलं (ग) महास्थूलं for (महास्थूलम्)
 २. स्थूलावनतिश्च (ग) for (स्थूलावनतिश्च)
 ३. वनती (ग) चनती for (वनति)
 (च) १. महास्थूलं for (महास्थूलम्)
 २. स्थूलावनतिश्च for (स्थूलावनतिश्च)
 ४. दशज्यया for (दृशज्यया)
 ३. लंबनावनती for (लंबनावनति)
३३. (घ) १. चतुष्क (ग) (च) for (चतुष्टु)
 २. स्थूलः (ग) (च) for (स्थूलः)
 ३. मानार्थं (ग) (च) for (मानार्थं)
 ४. महकृत (ग) (च) for (महकृत्)

विक्षेपगुणाक्षज्या^१ लंबकभक्ता^४ ग्रहे^२ मृणधनं^५ यत् ।
 उक्तमुदयास्तसमयो^३न्न^५ प्रतिघटिकं^५ ततस्तदसत् ॥ ३४ ॥
 त्रिज्या^६ कृत्या^७ भक्ता^८ विक्षेपापक्रमगुणो^९ क्रमज्येदोः ।
 अयनतिमृणधनं^१ न तदयनादौ^२ ततो^३ सा^४ तत् ॥ ३५ ॥
 दक्कणं^५ विज्ञानात्^६ कालाविज्ञानमकथितत्वाच्च ।
 कालज्ञानाद्धंकोरज्ञानं^७ कोटिनाशोतः ॥ ३६ ॥
 शशिशंकोः^८ शच्यपराकोटि^९भुजवर्ग^{१०}युतिमूलम् ।
 तिर्यक्करणो^{११} न भवति यतो^{१२} चन्द्रांतरं^{१३} कर्णः ॥ ३७ ॥

३४. (घ) १. गुण for (गुणा)
 २. ग्रहे (ग) ग्रहेष्ट्वृण for (ग्रहे)
 ३. मययो (ग) for (समयो)
 (ग) ४. व्या for (ज्या)
 ५. नप्रतिघटिकं for (नप्रतिघटिकं)
 (च) १. गुणाक्षज्या for (गुणाक्षज्या) २. ग्रहे for (ग्रहे)
३५. (घ) १. यदृण (ग) (च) for (मृण)
 २. ततो (ग) for (ततो)
 ३. सत्तत् (च) for (सातत्)
 (ग) ४. विक्षेपायनगुणोत् for (विक्षेपापक्रमगुणो)
 ५. तत्तस्यादौ for (ततदयनादौ)
 (च) ६. कृत्या for (कृत्या) ७. गुणोत्क्रम for (गुणोत्क्रम)
३६. (घ) १. दक्कणं (ग) (च) for (दक्कणं)
 २. विज्ञानात् for (विज्ञानात्)
३७. (घ) १. प्राच्य (ग) (च) for (शच्य)
 २. कोटिकोठि (ग) कोटिः कोटि for (कोटि)
 ३. यंतोर्कचंद्रांतरं (ग) for (यतोचंद्रांतरं)
 (ग) ४. वर्ग for (वर्ग)
 (च) ३. यंतो for (यतो)

कोटिश्रवणज्ञानात् शशिना शृङ्गोन्नतिर्विसंवदति ।

उदयास्तमयो दिनकृतः प्रतिघटिकं माती च वाज्ञानात् ॥ ३८ ॥

अर्कद्वतरघटिका व्यस्तज्या चन्द्रमानगुणिता यत् ।

व्यास विभक्ता शुद्धं यतो न द्रक् सममसत्तस्मात् ॥ ३९ ॥

प्राक् गुदितोभ्यधिकः पश्चाद्दिनकोयरेव्यस्तः ।

कालो यः छायायर्थं तदसत्स्फुटभुक्तिमान् प्राक् ॥ ४० ॥

उदितामुदितास्तमितावशेषकालान्न वेत्ति यः स कथम् ।

आर्यभट्टज्ञः शशिनः छाया शृङ्गोन्नतिर्वेत्ति ॥ ४१ ॥

३८. (घ) १. ज्ञाना छशिन for (ज्ञानात् शशिना) (ग) छशिनः for (शशिना)
 २. प्रतिघटिकमतीव वा ज्ञानात् (ग) प्रतिघटिकमतीव चाज्ञानात् for (प्रति-
 घटिकं माती च वा ज्ञानात्)
 (ग) ३. श्रवणा for (श्रवण)
 ४. विसंवदतिः for (विसंवदति)
 ५. दिनकृतः for (दिनकृतः)
 (च) १. ज्ञाना छशिना for (ज्ञानात् शशिना)
 २. प्रतिघटिकमती च for (प्रतिघटिकं माती च)
 ३९. (घ) १. अर्कद्वतर (ग) (च) for (अर्कद्वतर)
 २. द्रक्सम (ग) (च) for (द्रक्सम)
 (ग) ३. गुणिता for (गुणिता)
 ४. शुक्लं (च) for (शुद्धं)
 ४०. (घ) १. प्राक् गुदितोभ्यधिकः (ग) प्राक् प्रागुदितोभ्यधिकः for (प्राक् गुदितोभ्य-
 धिकः)
 २. उदितो न कोपरे व्यस्तः (ग) (च) for (उदिनकोयरे व्यस्तः)
 ३. कालो छायायर्थं (ग) कालौ य स्थाययर्थं for (कालो यः छायायर्थं)
 ४. भुक्तिमानात् प्राक् (ग) भुक्तिगमना प्राक् for (भुक्तिमान् प्राक्)
 (च) १. प्राक्गुदितोभ्यधिकः for (प्राक् गुदितोभ्यधिकः)
 ४१. (घ) १. मुदिता (ग) (च) for (मुदिता)
 २. कालान्न for (कालान्न)
 ३. शशिन (ग) शशिनस्छाया for (शशिनः छाया)
 ४. शृङ्गोन्नती (ग) (च) for (शृङ्गोन्नति)
 ५. वेत्ति (ग) (च) for (वेत्ति)
 (ग) ३. शशिन for (शशिनः)

स्वयमेव नामय कृतमार्यभटेन स्फुटं स्वगणितस्य ।
 सिद्धांतदस्फुटत्वं ग्रहणार्दानां विसंवदति ॥ ४२ ॥
 जानात्येकमपि यतो नार्यभटोगणितकालगोलानाम् ।
 न मया प्रोक्तोनि ततः पृथक् पृथक् दुषणात्येषाम् ॥ ४३ ॥
 आर्यभटदुषणानां संख्या वक्तुं न शक्यते यस्मात् ।
 तस्मादयमुद्देश्यो बुद्धिमत्तान्यानि योज्यानि ॥ ४४ ॥
 कालांतरेण दोषा येन्यैः प्रोक्ता न ते मयाभिहिताः ।
 किं ते दृष्येष्वथ दूषकेषु कोशोऽत्र पेयः स्थात् ॥ ४५ ॥
 श्रोषेणविष्णुचन्द्रप्रद्युम्नार्यभटलार्दासंहानाम् ।
 ग्रहणादिविसंवादात् प्रतिदिवसं सिद्धमकृत्वम् ॥ ४६ ॥

४२. (घ) १. यत्कृत (ग) (च) for (यकृत)
 २. सिद्धं (ग) (च) for (सिद्धांत)
 ३. ग्रहणादीनां (च) for (ग्रहणार्दानां)
 ४. विसंवादात् (च) for (विसंवदति)
४३. (घ) १. जानात्येकमपि (च) for (जानात्येकमपि)
 २. प्रोक्तानि (ग) for (प्रोक्तोनि)
 ३. पृथग्दूषणान्येषाम् (ग) पृथग्दूषणान्येषाम् for (पृथक्दुषणात्येषाम्)
 (ग) ४. तार्य for (नार्य)
 ५. काकाल for (काल)
 (च) ३. पृथग्दूषणान्येषां for (पृथक्दुषणात्येषाम्)
४४. (घ) १. दूषणानां (ग) दूषणानां for (दुषणानां)
 २. मुद्देशो (ग) (च) for (मुद्देश्यो)
 (च) १. दूषणानां for (दुषणानां)
४५. (घ) १. दृष्येष्वथ (ग) दृष्येष्वथ for (दृष्येष्वथ)
 २. स्थात् (च) for (स्थात्)
 (ग) ३. कालानांतरेण for (कालांतरेण)
 ४. दूषकेषु for (दूषकेषु)
 (च) १. दृष्येष्वथ for (दृष्येष्वथ)
४६. (ग) १. सिद्धमकृत्वम् for (सिद्धमकृत्वम्)
 (च) १. मकृत्वं for (मकृत्वम्)

युत्तधार्यभटोक्तानि प्रत्येकं दूषणानि योज्यानि ।
 श्रीषेण प्रभृतीनां कानिचिदन्यानि वक्ष्यामि ॥ ४७ ॥
 लाटात्सूर्यशशांकौ मध्याविन्दुच्च चंद्रपातौ च ।
 कुजबुधशीघ्रबृहस्पतिसितशीघ्रशनैश्चरान्मध्या ॥ ४८ ॥
 युगयातवर्षभरणान् वाशिष्ठान् विजयनंदिकृतपादान् ।
 मंदोच्चपरिधिपातस्पष्टीकरणाद्यमार्यभटात् ॥ ४९ ॥
 श्रीषेण ग्रहित्वा चन्द्ररत्नोच्चयरोमकः कृतः ।
 कथा एतान्येव गृहीत्वा वसिष्ठो विष्णुचन्द्रेण ॥ ५० ॥
 अनयोर्न कदाचिदपि ग्रहणादिषु भवति दृष्टिगणितैक्यम् ।
 यद् भवति तद्बुगुणाक्षरमतो स्फुटान्यां किमेताभ्याम् ॥ ५१ ॥

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४७. (घ) १. दूषणानि (ग) (च) for (दूषणानि)
 २. कानिचिदन्यानि for (कानिचिदन्यानि)
४८. (घ) १. विन्दुच्च (ग) (च) for (विन्दुच्च)
 २. मध्यात् (ग) for (मध्या)
 (च) ३. लाटा for (लाटात्)
४९. (घ) १. यान for (यात) २. कृत (ग) कृतम् for (कृत)
 ३. मंदोच्चपरिपात (ग) मंदोच्चपरिधिपातः for (मंदोच्चपरिधिपात)
 (ग) ४. वाशिष्ठाद्विजयनंदि for (वाशिष्ठान् विजयनंदि)
 ५. पादम् for (पादान्)
 (च) १. युगपात for (युगयात)
५०. (घ) १. श्रीषेण गृहीत्वा (ग) श्रीषेणगृहीत्वा for (श्रीषेण ग्रहित्वा)
 २. कथा (पहली पंक्ति के अन्त में) for (कथा)
 ३. वासिष्ठो (ग) (च) for (वासिष्ठो)
 (ग) ४. 'चन्द्र' यहां अंकित नहीं ५. ग्रहीत्वा for (गृहीत्वा)
 (च) १. श्रीषेणेन गृहीत्वा for (श्रीषेण ग्रहित्वा)
 ५. कृतः for (कृतः)
५१. (घ) १. तद्बुगुणाक्षर (ग) तद् बुगुणाक्षर for (तद्बुगुणाक्षर)
 (च) १. तद्बुगुणाक्षर for (तद्बुगुणाक्षर)

नाचोच्चवृत्तमध्यस्य गोलबाह्येन नामकृतमुच्चम् ।
 तस्थो न भवत्युच्चो यतस्ततो वेत्ति नोच्चमपि ॥ ५२ ॥
 अन्या विक्षेपकला मंदान्यत्वात्फलाधिकाः स्पष्टाः ।
 यस्मान्माहायुगादौ न राहुमंदाः स्फुटात्तस्मात् ॥ ५३ ॥
 परमालाब्दमित्युनांते द्युरात्रि नाड्योर्गतिवशाद्वृत्तवः ।
 नायनयुगमयनवशात् स्थिरमयी तद्वितयमपि तस्मात् ॥ ५४ ॥
 तद्युगवधो महायुगमुक्तं श्रीषेणविष्णुचन्द्राद्यैः ।
 तत्स्थूलं दृग्लिप्ता माहायुगादौ ग्रहेषु यतः ॥ ५५ ॥
 कदिनादौ स्मृतियुक्तं ग्रहभोत्पत्तिदिनक्षये प्रलयः ।
 तान्यपि बहूनि यस्मान्माहायुगेऽतो प्रसिद्धमिदम् ॥ ५६ ॥

५२. (घ) १. नीचोच्च (ग) नीचोच्चावृत्त for (नाचोच्चवृत्त)
 २. तास्था for (तस्थो)
 (च) १. नीचोच्च for (नाचोच्च)
५३. (घ) १. फलाधिका (च) for (फलाधिकाः)
 २. महा (ग) (च) for (माहा)
 ३. स्फुटाः तस्मात् (ग) स्फुटास्तस्मात् for (स्फुटात्तस्मात्)
 (च) ३. स्फुटाः तस्मात् for (स्फुटात्तस्मात्)
५४. (घ) १. परमाल्पा (ग) परिमाल्पा for (परमालाब्द)
 २. स्थिरमय (ग) for (स्थिरमयी)
 (ग) ३. न द्वितयमपि for (तद्वितयमपि)
 (च) १. परमाल्पाब्द for (परमालाब्द) २. स्थिरमपि for (स्थिरमयी)
५५. (घ) १. स्थूलं (ग) for (स्थूलं) २. महा for (माहा)
 (ग) ३. मयाहायुग for (माहायुग)
 (च) ३. तत्स्थूलं for (तत्स्थूलं) २. माहायुगादौ for (माहायुगादौ)
५६. (घ) १. स्मृतिषुक्तं (ग) स्मृतिषूक्तं for (स्मृतियुक्तं)
 २. बहूनि (ग) for (बहुनि)
 (ग) ३. पत्तिदिनक्षये for (पत्तिदिनक्षये) ४. युगेतो for (युगेऽतो)
 (च) १. स्मृतिषुक्तं for (स्मृतियुक्तं)
 ३. ग्रहभोत्पत्तिदिनक्षये for (ग्रहभोत्पत्तिदिनक्षये)

प्रतिदिवस विसंवादात्^१ ग्रहतिथिकरणार्थं दिवसमानानाम् ।
 ग्रहणग्रहयोगादिषु पादं पादेन कः स्पृशति ॥ ५७ ॥
 अंगचितिविजयनंदिप्रद्युम्नादीनि पादकरणानि ।
 यस्मात्तस्मात्तेषां^२ दूषणान्यत्र लिखितानि ॥ ५८ ॥
 इति बहुधा विवदंति ग्रहार्थिनः सद्ग्रहा इव प्रसभम् ।
 ब्राह्मे स्फुटसिद्धान्ते रवीन्दु भूयोगमज्ञात्वा ॥ ५९ ॥
 तंत्रभ्रंशं प्रतिदिनमेवं विज्ञाय धीमता यत्नः ।
 कार्यस्तस्मै दृग्गणितैक्यं सदा भवति ॥ ६० ॥
 चन्द्ररविग्रहणैर्दुःखादिषु सर्वदा यतो ब्राह्मे ।
 दृग्गणितैक्यं भवति स्फुटसिद्धान्तस्ततो ब्राह्मे ॥ ६१ ॥
 यो यज्जनात्तेषां स वेत्ति तदुषणानि कथितानि ।
 आर्यभटाद्युक्तानां तन्त्राणां दूषणाध्याये ॥ ६२ ॥

५७. (घ) १. विसंवादाद्ग्रह for (विसंवादाद्ग्रह) (च) विसंवादाद्ग्रह for (विसंवादाद्ग्रह)
५८. (घ) १. अंकचिति (ग) अंकयिति for (अंगचिति)
 (ग) २. 'न' यहां अतिरिक्त है ।
 (च) १. अंकचिति for (अंगचिति) २. +न+
५९. (घ) १. ग्रहार्थिनः (ग) ग्रहार्थिनः for (ग्रहार्थिनः)
 (ग) २. सद्ग्रहा for (सद्ग्रहा) ३. मत्कृत्वा for (मज्ञात्वा)
६०. (घ) १. विज्ञाया (च) for (विज्ञाय) २. धीमता (ग) (च) for (धिमता)
 ३. यत्ना (ग) यत्नः for (यत्नः) ४. तस्मि (ग) तस्मिन्यस्मिन् for (तस्मै)
 ५. दृग्गणितै किं for (दृग्गणितैक्यं)
 (च) ४. कार्यस्तस्मि for (कार्यस्तस्मै)
६२. (घ) १. यं जानात्तेषां (ग) यं जानात्येषां for (यज्जनात्तेषां)
 २. दूषणानि (ग) for (दुषणानि)
 ३. दूषणाध्याये ग) (च) for (दुषणाध्याये)
 (च) १. यो यज्जनात्तेषां for (यो यज्जनात्तेषां)
 २. तदूषणानि for (तदुषणानि)

इति^४ कथिततन्त्राणां^१कान्पठतिरपि^२ दूषणैः करोत्यज्ञानात्^५ ।
 तन्त्र परीक्षार्यणां^३ त्रिषष्टिरेकादशोऽध्यायः ॥ ६३ ॥
 इति^६ श्री ब्रह्मगुप्तसिद्धान्ते एकादशोऽध्यायः ।

६३. (घ) १, २. तन्त्रगणकान्यदितैरपि (ग) तन्त्रगणकान् पठितैरपि for (तन्त्राणाका-
 न्पठतिरपि)

३. परीक्षार्यणाम् (ग) for (परीक्षार्यणां)

(ग) ४. इति for (इति) ५. करोत्यज्ञान् for (करोत्यज्ञानात्)
 समाप्तिसूचक चिह्न छः छः छः

(च) १. तन्त्रगणकान्यदितैरपि for (तन्त्राणाकान्यठतिरपि)

५. करोत्यज्ञान् for (करोत्यज्ञानात्)

२. परीक्षार्यणां for (परीक्षार्यणां) ६. 'इति' से 'अध्यायः' तक सब लुप्त ।

अथ गणिताध्यायः

द्वादशः

परिकर्मं विंशति यः संक(व)लिताद्यं पृथक् विजानाति ।
 अष्टौ च व्यवहारान् छायातान् भवति गणकः सः ॥ १ ॥
 विपरीत छेदगुणाः राश्योः छेदांशकाः समछेदाः ।
 संकलितेशा योज्या व्यवकलितेशांतरं कार्यम् ॥ २ ॥
 रूपाणि छेदगुणान्यंशयुतानि द्वयोर्बहुनां वा ।
 प्रत्युत्पन्नो भवति छेदवधेनोद्धृतांशवधः ॥ ३ ॥
 प्रत्युत्पन्नः परिवृत्य भागहारछेदांशौ छेदसंगुणछेदः ।
 अंशांशगुणो भाज्यस्य भागहारः सर्वाणितयोः मागहारः ॥ ४ ॥

१. (घ) १. विंशति (ग) for (विंशति) २. संकलिताद्यां (ग) (च) for (संकलिताद्यं)
 ३. पृथक्विजानाति (ग) (च) for (पृथक् विजानाति)
 ४. व्यवहां (ग) व्यवहारांस् for (व्यवहारान्)
 ५. छायातान् (ग) (च) for (छायातान्)
 (ग) ६. परिकर्म for (परिकर्म)
२. (घ) १. संकलितेशा (ग) (च) संकलितेशा for (संकलितेशा)
 (ग) २. गुणा for (गुणाः) ३. राश्योश्छेदांशकाः for (राश्योः छेदांशकाः)
३. (घ) १. बहूनां (ग) for (बहुनां)
 २. वधेनोद्धृतांशवधः (ग) वधेनोद्धृतांशवधः for (वधेनोद्धृतांशवधः)
 (च) १. बहूनां for (बहुनां) ३. प्रत्युत्पन्नो for (प्रत्युत्पन्नो)
 २. वधेनोद्धृतांशवधः for (वधेनोद्धृतांशवधः)
४. (घ) १. शंगुण for (संगुण) २. भाज्यस्य (च) for (भाज्यस्य)
 ३. सर्वाणितयोः (ग) सर्वाणितयोः for (सर्वाणितयोः)
 वि० यहाँ श्लोक समाप्त ।
 ४. भागहारः (च) for (भागहारः)
 (ग) ५. परिवृत्य (इसी पद से श्लोकारंभ होता है)
 ६. भाहारः for (भागहारः)
 वि०-इस श्लोक में “प्रत्युत्पन्नः” और “भागहारः” पद अंकित नहीं हैं ।
 (च) ७. छेदांशौ for (छेदांशौ)

सर्वाणितांशवर्गछेदकृति विभाजितो भवति वर्गः ।

सर्वाणितांशमूलं छेदपदेनोद्धृते मूलम् ॥ ५ ॥

वर्गमूलो स्थाप्योत्पद्यनोन्यकृतिस्त्रिगुणोत्तरसंगुणा च यत्प्रथमा ।

नोत्तरकृति रत्यगुणा त्रिगुणा चोत्तर घनदच घनः ॥ ६ ॥ घनः समाप्तः

छेदोघना द्वितीयात् घनमूलकृतिस्त्रिगुणा सकृतिः ।

शोध्य त्रिपूर्वगुणिता प्रथमात् घनतो घनो मूलं ॥ ७ ॥ घनमूलं समाप्तः

घनमूलं समाप्तः

५. (घ) १. पदेनोद्धृतं (ग) (च) for (पदेनोद्धृते)

(ग) २. वर्गः for (वर्गः)

६. (घ) १. वर्ग (‘वर्गमूलो’ यह शब्द पांचवें श्लोक का अंतिम पद है)

२. स्थाप्योत्पद्यनो (ग) स्थाप्योत्पद्यनोन्यकृति for (स्थाप्योत्पद्यनो)

३. न्यकृति for (न्यकृति) ४. तत् (ग) तत्प्रथमान् for (यत्प्रथमा)

५. उत्तरकृति (ग) उत्तरकृतिरत्यगुणा for (उत्तरकृति)

६. त्रिगुणा (ग) त्रिगुणाचोत्तर for (त्रिगुणा)

७. समाप्तः for (घनः समाप्तः)

(ग) १. यह पद यहाँ लुप्त है । ८. संगुणो for (संगुणा)

(च) २. स्थाप्योत्पद्यनोन्यकृति for (स्थाप्योत्पद्यनोन्यकृति)

५. उत्तरकृति for (नोत्तरकृति) ६. रत्यगुणा for (रत्यगुणा)

७. समाप्तः for (घनः समाप्तः)

७. (घ) १. द्वितीयाद्धनमूल (ग) द्वितीयाद्धनमूल for (द्वितीयात् घनमूल)

२. संगुणाप्तकृतिः (ग) for (संगुणाप्तकृतिः)

३. समाप्तम् for (समाप्तः)

(ग) ४. छेदाघना for (छेदोघना)

५. प्रथमाद्धनमूलं for (प्रथमात् घनतो घनमूलं)

वि०-‘घनमूलं.....समाप्तः’ शब्द अंकित नहीं है ।

(च) १. द्वितीयाद्धनमूलकृति for (द्वितीयात् घनमूलकृति)

२. संगुणाप्तकृतिः for (संगुणाप्तकृतिः)

५. प्रथमाद्धनतो for (प्रथमात् घनतो)

३. घनमूलं समाप्तं for (घनमूलं समाप्तः)

६. ‘घन’ से ‘समाप्तः’ तक लुप्त

सदृशछेदांशयुतिछेदविभक्ताफलं प्रथमजातौ ।

अंशैरेशागुणिता छेदै छेदा द्वितीयाभ्याम् ॥८॥ प्रथमद्वितीयजाति समाप्तः

ऊर्द्धांशा छेदगुणास्तृतीयजातौ द्वयोः पृथक् परयोः ।

छेदै छेदा गुणिताः स्वांशयुतोनैरूपरिमांशाः ॥ ९ ॥

तृतीय चतुर्थीजाति स० ।

त्रैराशिके प्रमाणफलमिच्छाद्यंतयोः सदृशराशिः ।

इच्छाफलेन गुणिता प्रमाणभक्ताफलंभवति ॥ १० ॥ त्रैराशिकं स०

व्यस्तत्रैराशिकफलामिच्छाभक्तः प्रमाणफलघातः । व्यस्तत्रैराशिकं स०

त्रैराशिकादिषु फलं विषमेष्वेकादशांतेषु ॥ ११ ॥

८. (घ) १. रंशा (ग) for (रेशा)

(ग) २. सदृश for (सदृश) ३. युतिछेद for (युतिछेद)

४. छेदैरेछेदा for (छेदैरेछेदा)

५. “प्रथम.....समाप्तः” शब्द अंकित नहीं है ।

(च) १. अंशैरंशा for (अंशैरेशा)

९. (घ) १. रूपरिमांशाः (च) for (रूपरिमांशाः) २. समाप्तेः for (स०)

(ग) ३. ऊर्द्धांशाश्छेद for (ऊर्द्धांशाछेद) ४. छेदैरेछेदा for (छेदैरेछेदा)

५. युतेता for (युतो)

वि० “तृतीय...से जाति स०” तक अंकित नहीं है ।

(च) २. जाती समाप्ते for (जाति स०)

१०. (घ) १. राशी (ग) (च) for (राशिः) २. प्रमाणक्ता for (प्रमाणभक्ता)

३. समाप्तम् for (स०)

(ग) “त्रैराशिकं समाप्तं” शब्द अंकित नहीं है ।

(च) समाप्तं for (स०)

११. (घ) १. फलमिच्छा (ग) for (फलामिच्छाभक्तः)

२. दृश्यंतेषु for (दशांतेषु) ३. समाप्तम् for (स०)

(ग) ३. ‘व्यस्त’ से ‘स०’ तक यहां अंकित नहीं है ।

(च) २. दृश्यंतेषु for (दशमंतेषु)

फलं संक्रमणमुभयतो बहुराशिवधे तुलवधहृतो ज्ञेयः ।

सकलेष्वेवं भिन्नेषु भयतछेदसंक्रमणं ॥ १२ ॥

पंचसप्तनवैकादशराशि समाप्तानि ।

प्राग् मूल्यव्यत्यासो भांडप्रतिभांडिकेत्युक्तः ।

समपरिकर्मान्यष्टानां व्यवहाराणामभिहितानि ॥ १३ ॥

कालगुणितं प्रमाणं फलभक्तं व्येकगुणहृतं कालः ।

स्वफलयुतरूपभक्तं मूलफलैवयं भवति मूलम् ॥ १४ ॥

कालप्रमाणघातः परकालहृतो द्विधाद्यमिश्रवधात् ।

अन्याद्धैकृतियुतात्पदमन्याद्धौन प्रमाणफलम् ॥ १५ ॥

१२. (घ) १. फल for (फलं) २. मुयतो for (मुभयतो)

३. वधेऽल्पवध (ग) वधाऽल्पवधहृतो (कृतो) for (वधेतुलवधहृतो)

४. भन्नेषु (ग) भिन्नेषुभयतश्छेद for (भिन्नेषुभयतछेद)

५. राशिकानि for (राशि) (च)

(ग) ५. 'पंच' से 'समाप्तानि' तक पद यहां अंकित नहीं है ।

(च) १. फल संक्रमण for (फलं संक्रमण)

३. तुल्यवधहृतो for (तुलवधहृतो)

१३. (घ) १. भ्यंडप्रतिभ्यंडिके for (भांडप्रतिभांडिके)

२. इत्युक्त (ग) न्यदुक्तसमम् for (त्यदुक्तः)

३. सम (ग) for (सम)

४. परिकर्मान्यष्टानां (ग) परिकर्मान्यष्टानां for (परिकर्मान्यष्टानां)

(ग) ५. परिकर्मान्यष्टानां for (परिकर्मान्यष्टानां)

१४. (ग) १. हृतं (च) for (हृतं)

१५. (ग) १. मन्याद्धौनम् for (मन्याद्धौन)

(च) २. कृति for (कृति) ३. पदमन्याः दौन for (पदमन्याद्धौन)

प्रश्नेपयोगहृतया लब्धा^२ प्रश्नेपका^३ गुणा लाभाः ।

ऊनाधिकोत्तराद्ध^४स्तद्यु^५तो नया स्वफलमूनं युतम् ॥ १६ ॥

मिश्रक व्यवहार समाप्तः

पदमेकहीनमुत्तरगुणितं संयुक्तमादिनांत्यधनम् ।

आदि युतान्त्यधनाद्ध^१मध्यधनं पदगणं गुणितम् ॥ १७ ॥

उत्तरहीनाद्विगुणादिशेषवर्गं धनोत्तराष्ट्रवधे ।

प्रक्षिप्य^३ पदं शेषोनं द्विगुणोत्तरं हृतं गच्छः ॥ १८ ॥

एकोत्तरमेकाद्यं यदिष्टगच्छस्य भवति संकलितम् ।

तद् वियुतं गच्छ गुणितं तु हृतं संकलितम् ॥ १९ ॥

१६. (घ) १. प्रक्षेपयोगहृतया (ग) (च) for (प्रश्नेपयोगहृतया)

२. लब्धा for (लब्धा) ३. प्रक्षेपका (ग) प्रक्षेपक for (प्रश्नेपका)

४. त्तरास्तद्युतो (ग) (च) for (त्तराद्धस्तद्युतो)

५. मूनयुतम् (ग) (च) for (मूनयुतम्)

(ग) 'मिश्रक' से 'समाप्तः' तक अंकित नहीं है ।

(च) २. प्रक्षेपका for (प्रश्नेपका)

६. व्यवहारः for (व्यवहार)

१७. (ग) १. पदगुणं for (पदगणं) २. गणितम् for (गुणितम्)

१८. (घ) १. उत्तरहीन (ग) (च) for (उत्तरहीना) :

२. शेषवर्गं (ग) (च) शेषवर्गं for (शेषवर्ग)

३. प्रक्षिप्य (ग) (च) for (प्रक्षिप्य)

४. हृतं (ग) यह पद अंकित नहीं है । for (हृतं)

(ग) ५. द्विगुणोत्तरं for (द्विगुणोत्तर)

(च) ४. हृतं for (हृतं)

१९. (घ) १. यदिष्ट (ग) (च) for (यदीष्ट) २. गच्छस्य (ग) (च) for (गच्छस्य)

३. हृतं (ग) त्रिहृतं for (तूहृतं)

(ग) ४. एकोत्तरमेकाद्यं for (एकोत्तरमेकाद्यं)

५. गच्छ for (गच्छ) ६. संकलितं संकलितम् for (संकलितम्)

(च) ५. वियुतगच्छ for (वियुतगच्छ) ३. त्रिहृतं for (तूहृतं).

द्विगुणपदसैकगुणितं तत्रूहृतं भवति वर्गसंकलितम् ।

घूनसंकलितं तत्कृतिरेषां समगोलकैश्चितयः ॥ २० ॥

श्रेष्टीव्यवहार समाप्तः ॥

स्थूलफलं त्रिचतुर्भुजबाहुप्रतिबाहुयोगदलघातः ।

भुजयोगाद्वचतुष्टवभुजो न घातात्पदं सुक्ष्मम् ॥ २१ ॥

भुजकृत्यन्तरभूहृतहीनयुताभूद्विभाजिता बाधे ।

स्वाबाधावर्गोनाद्भुजवर्गान्फलमवलंब ॥ २२ ॥

अविषमचतुस्त्रभुजगतिभुजवधयोर्युते पदं कर्णः ।

कर्णाकृतिभूमुखयुतिदल व(प)र्गो नापदं लंब ॥ २३ ॥

२०. (घ) १. तत्रूहृतं (ग) तत् त्रिहृतं for (तत्रूहृतं)
 २. घन (ग) घनसंकलित for (घूनसंकलितं)
 ३. तत्कृति (ग) for (तत्कृति) ४. श्रेष्टी व्यवहारः for (श्रेष्टी व्यवहार)
 (ग) ५. संलितम् for (संकलितम्)
 ४. वि० 'श्रेष्टी' से 'समाप्तः' तक यहाँ अंकित नहीं है ।
- (च) १. तत्रूहृतं for (तत्रूहृतं) २. घनसंकलितं for (घूनसंकलितं)
 ३. तत्कृति for (तत्कृति) ४. श्रेष्टी for (श्रेष्टी)
२१. (घ) १. सूक्ष्मम् (ग) for (सुक्ष्मम्)
 (च) १. सूक्ष्मं for (सुक्ष्मम्)
२२. (घ) १. भूहृतं (ग) भूहृतहीन for (भूहृतं)
 २. मूलमवलंबः (ग) मूलमवलंब for (फलमवलंब)
 (ग) ३. भूद्विभाजिता बाधे for (भूद्विभाजिता बाधे)
 (च) १. भूहृतं for (भूहृतं) २. मूलमवलंबः for (फलमवलंब)
२३. (घ) १. भुजगतिभुजगति (ग) भुजप्रतिभुजवधयो for (भुजगतिभुजवधयो)
 २. भुजवधयोर्युतेः (ग) युतेः for (भुजवधयोर्युते)
 ३. लंबः (ग) (च) for (लंब)
 (ग) ४. चतुस्त्र for (चतुस्त्र)
 (च) २. युतेः for (युते)

कर्णकृतेः कोटिकृतं विशोध्य मूलं भुजो भुजस्य कृति ।
 प्रोह्य यदं कोटिबाहु कृतियुतिपदं कर्णः ॥ २४ ॥
 कर्णयुतादुर्द्धाधिरखण्डे कर्णावलंबयोगे ।
 वास्वाबाधे स्वयुतिहते द्विधा प्रथक्कर्णलंबगुणे ॥ २५ ॥
 अविषमपादर्वभुजगुणकर्णो द्विगुणोवलंबकविभक्तः ।
 हृदयं विषमस्यभुजः प्रतिकृतिभुजकृतियोगमूलार्द्ध ॥ २६ ॥
 त्रिभुजस्य बधोभुजयोर्द्विगुणितलंबोद्धृतो हृदयरजः ।
 नृचतुर्भुजहृदय द्विगुणं वहिवृत विष्कुंभः ॥ २७ ॥

२४. (घ) १. कृति (ग) कृति for (कृतं)
 २. प्रोह्य पदं कोटिः (ग) for (प्रोह्ययदं कोटि)
 (ग) ३. विशोध्य for (विशोध्य)
 (च) १. कृति for (कृतं)
२५. (घ) १. वा (इस पंक्ति का अंतिम शब्द 'वा' है) (ग)
 २. (दूसरी पंक्ति 'स्वा—' से आरम्भ होती है) (ग)
 ३. हिते (ग) हते द्विधा पृथक् for (हतेद्विधा प्रथक्)
 (ग) ४. मूर्ध्ना for (दुर्द्धा)
 (च) ४. दुर्द्धाधिर for (दुर्द्धाधिर) ३. हते for (हते)
२६. (घ) १. गुणः (ग) (च) for (गुण)
 २. (यहां 'कृति' शब्द मूल पाठ में नहीं है) (ग)
 (ग) ३. द्विगुणावलंबक for (द्विगुणोवलंबक)
 ४. विषमभुजः for (विषमस्यभुजः)
 (च) २. 'कृति' लुप्त
२७. (घ) १. हृदयं (ग) (च) for (हृदय)
 २. वृत्तं (ग) वृत्त for (वृत्त)
 ३. विष्कुंभः for (विष्कुंभः)
 (ग) ४. त्रुजयो for (भुजयो) ५. लंबोद्धृतो for (लंबोद्धृतो)
 ६. त्रि for (नृ) ७. द्विगुणितं for (द्विगुणं)
 (च) २. वृत्तं for (वृत्त)

कर्णास्त्रितभुजघातैकामुभयथान्योन्यभाजितं गुणयेत् ।
 योगेन भुजप्रतिभुजवधयोः कर्णोपदे विषमे ॥ २८ ॥
 विषमचतुरस्त्रमध्ये विषमत्रिभुजद्वयं प्रकल्प पृथक् ।
 कर्णद्वयेन पूर्ववदाबाधे लंबकौ च पृथक् ॥ २९ ॥
 विषमभुजांतस्त्रिभुजे प्रकल्प्य कर्णौ भुजो तदावधे ।
 पृथग्पूर्वा धरखण्डे कर्णयुतौ कर्णयोरधरे ॥ ३० ॥
 त्रिभुजभुजौ भूमिस्तल्लंबो उर्ध्वमवलंब खण्डम् ।
 लंबकयोगाद्धं मधरोनम् ॥ ३१ ॥

२८. (घ) १. कर्णासुत (ग) कर्णाश्रित for (कर्णास्त्रित)
 २. घातैक्य (ग) घातैः क्य for (घातैका)
 (ग) ३. 'ज' अंकित नहीं है ४. कर्णौ for (कर्णों)
 (च) १. कर्णासुत for (कर्णाश्रित) २. घातैक्यमुभयथा for (घातैकामुभयथा)
२९. (घ) १. चतुरस्त्रमध्ये (च) for (चतुरस्त्रमध्ये)
 (ग) २. विषम for (विषम)
३०. (घ) १. बाधे (ग) तदा माबाधे for (तदावधे)
 (ग) २. ये for (जे)
 ३. कर्णौ भुजौ । (यहां पहली पंक्ति समाप्त — दूसरी पंक्ति 'तदा' से आरम्भ)
 ४. चरण्डे for (घरखण्डे)
 (च) २. त्रिभुजे for (स्त्रिभुजे)
 ३. कर्णौभुजौ for (कर्णौभुजो) ४. पृथग्पूर्वाधरखण्डे for (पृथग्पूर्वाधरखण्डे)
३१. (घ) वि०—यहां इस श्लोक का उत्तरार्ध लिखना लिपि कार भूल गया प्रतीत होता है, '३१' का संख्याक्रम भी नहीं मिलता ।
 १. भूमि for (भुमि) २. लंबयोरधरे (ग) लंबकाधरं for (उर्ध्वमवलंब)
 (ग) १. भूमि for (भुमि) ३. दूसरी पंक्ति - ऊर्ध्वमवलंबखंडं लंबकयोगाद्धंमधरोनम्
 (च) १. भूमिस् for (भुमिस्)
 वि०—यह श्लोक यहां ३१ व ३२ मिला जुला इस प्रकार है—
 त्रिभुजभुजौ भूमिस्तल्लंबोऽर्ध्वमवलंबखंडं लंबकयोगाद्धंमधरोनम् ॥ ३१ ॥
 त्रि० देखांकित पदः से आगे का समस्तभाग ऊपर अन्यहस्त से लिखा हुआ है ।
 (ङ) ४. त्रिभुजे for (त्रिभुज) १. तुभूमि for (भूमि)
 २. लंबकाधरं for (उर्ध्वमवलंब) ३. + ऊर्ध्वमवलंबखण्डम् +

कर्णविलंकयुतौ खंडे कर्णविलंबयोरधरे ।
 अनुपातेन तुङ्गे उर्ध्वं शून्यांस पाटायाम् ॥ ३२ ॥
 कृतियुरसदृशराशयोर्बाहुधातो द्विसंगुणो लंबः ।
 क्रत्यन्तरमसदृशयोर्द्विगुणं द्विसमत्रिभुजममिः ॥ ३३ ॥
 इष्टद्वयेन भक्तो द्विष्टवर्गफलेष्टयोगाद्धे ।
 विषमत्रिभुजस्य भुजा विष्टोनफलाद्धे योगां भूः ॥ ३४ ॥
 इष्टस्य भुजस्य क्रतिर्भक्तो नेष्टेन तद्वलं कोटिः ।
 आयनचतुरस्रस्य क्षेत्रस्येष्टाधिका कर्णः ॥ ३५ ॥

३२. (घ) (वि०—पहली पंक्ति लिपिकार लिखना भूल गया प्रतीत होता है)

१. शून्यांस (ग) तव्यांस for (शून्यांस)

(ग) २. कर्णविलंबकयुतौ (च) for (कर्णविलंकयुतौ)

३. अनुपातेन for (अनुपातेन) ४. तङ्गे (ङ) for (तुङ्गे)

५. ऊर्ध्वं वेस् for (उर्ध्वं) ६. पाटायाम् for (पाटायाम्)

(च) ७. यहां क्रमसंख्या ३१ ही अंकित है ।

(ङ) २. कर्णविलंबकयुतौ for (कर्णविलंकयुतौ)

५. ऊर्ध्वे for (उर्ध्वं) १. शून्यांस for (शून्यांस)

३३. (घ) १. कृतियुतिर (ग) (च) for (कृतियुर)

२. क्रत्यन्तर (ग) (ङ) for (क्रत्यन्तर)

३. मसदृशयो (ग) (च) (ङ) for (मसदृशयो)

४. त्रिभुज भूमिः for (त्रिभुजममिः)

(ग) ५. धातो (च) (ङ) for (धातो)

६. द्विद्विसमत्रिभुजभूमिः for (द्विसमत्रिभुजममिः)

(च) ४. त्रिभुजभूमिः (ङ) for (त्रिभुजममिः)

(ङ) १. कृतियुतिर for (कृतियुर)

३४. (घ) १. इष्टद्वयेन for (इष्टद्वयेन)

(ग) २. वर्गः for (वर्ग) ३. विषमत्रिभुजस्य for (विषमत्रिभुजस्य)

(ङ) २. वर्गः for (वर्ग) ४. योगोभूः for (योगाभूः)

३५. (घ) १. कृति (ग) (च) (ङ) for (क्रति)

२. तद्वलं (ग) (ङ) for (तद्वलं) ३. आयत (च) (ङ) for (आयन)

४. चतुरस्रस्य (ग) (च) (ङ) for (चतुरस्रस्य)

आयतकर्णौ बाहु भुजकृतिरिष्टेन भाजितेष्टोना ।
 द्विहृता कोद्यधिकाभूर्मुखमूलानाद्विसमचतुरस्त्रे ॥ ३६ ॥
 कर्णकृतिस्त्रिसमभुजास्त्रयश्चतुर्थो विशोध्य कोटिकृति ।
 बाहुकृतेस्त्रिगुणार्या यद्यधिकोभूर्मुखं हीनः ॥ ३७ ॥
 जात्यद्वयकोटिभुजाः परकर्णगुणाः भुजाश्चतुर्विषमे ।
 अधिकोभूर्मुखमनो बाहु द्वितयं भुजावन्यौ ॥ ३८ ॥
 दृष्टगुणकारगुणितो गिर्युद्धायः पुरांतरमनष्टम् ।
 द्वियुतं गुणाकरभाजितमुत्पातोन्वस्य समगत्योः ॥ ३९ ॥
 व्यासव्यासाद्धकृतिपरिधिफले व्यासहारिके त्रिगुणे ।
 तद्वर्गाम्नां दशभिः संगुणिताभ्यां पदे सुक्ष्मे ॥ ४० ॥

३६. (घ) १. बाहु (ङ) for (बाहु) २. हृता (ङ) for (हृता)
 ३. मुखमूला (ग) for (मुखमूलाना)
 ४. चतुर (यहां 'चतुर' के पश्चात् 'स्त्रे' और संख्या क्रम लिखना लिपिकार भूल गया है) ।
 (ग) ५. आयनकर्णौ for (आयतकर्णौ)
 (च) ६. कृति for (कृति) ३. भूर्मुखमूलाना for (भूर्मुखमूलाना)
 (ङ) ७. कोद्यधिका for (कोद्यधिका) ३. भूर्मुखमूला for (भूर्मुखमूलाना)
 ३७. (घ) १. कृतिम् (ग) कृति for (कृति) २. भुजा (ग) (ङ) for (भुजा)
 ३. कृतिम् (ग) (ङ) (कृति) ४. कृते (ङ) for (कृते)
 ५. गुणायायद्यधिको (ग) (ङ) for (गुणार्यायद्यधिको)
 (च) ३. कृति for (कृति)
 (ङ) १. कृतिस् for (कृतिस्)
 ३८. (घ) १. कर्णगुणा (ग) हृता for (कर्णगुणाः) २. वन्यो for (वन्यौ)
 (च) १. गुणा for (गुणाः)
 (ङ) १. कर्णगुणा for (कर्णगुणाः)
 ३९. (घ) १. द्वियुत (ग) (ङ) for (द्वियुतं)
 (ग) २. गुणाकार (च) (ङ) for (गुणाकर) ३. समगत्यो for (समगत्योः)
 ४०. (घ) १. कृती (ग) कृती (ङ) for (कृति)
 २. व्यावहारिके (ग) (च) (ङ) for (व्यासहारिके)
 ३. तद्वर्गाम्नां (ग) तद्वर्गाम्नां (च) तद्वर्गाम्नां for (तद्वर्गाम्नां)
 ४. सुक्ष्मे (ग) (च) (ङ) for (सुक्ष्मे)

दृत्ते शरोन^१गुणितात्^५ व्यासाच्च^२तुराहतात्पदं जीवा ।
 ज्यावर्गश्च^३तुराहतशरभक्तः शरयुतो व्यासः ॥ ४१ ॥
 ज्याव्यासकृतिविशेषान्मूलव्यासांतराद्ध^३मिषुरल्पः ।
 व्यासो ग्रासोनगुणौ ग्रासो नैक्योद्धतौ^२ बाणौ ॥ ४२ ॥
 इष्टशरस्य^१ भक्ते ज्याद्ध^६ कृन्तिशरफले^३ युतौ^७ व्यासौ ।
 शरयोः पलयोरैक्यं^८ ग्रासौ ग्रासद्यदुनं^५ तत् ॥ ४३ ॥

४१. (घ) १. शरोत for (शरोन)

२. व्यासाच्चौ^२ (ग) द्वासा for (व्यासाच्चव)

३. ज्यावर्गस्य for (ज्यावर्गश्च) ४. तुराहह for (तुराहत)

(ग) ५. गुणिता for (गुणितात्)

(च) ५. गुणिताद्वासाच्च (ङ) for (गुणिताद् व्यासाच्च)

४२. (घ) १. व्यासौ (ग) (ङ) for (व्यासो)

२. ग्रासोनैक्याद्युतौ (ग) ग्रासोनैक्योद्धतौ^२ for (ग्रासोनैक्योद्धतौ)

(ग) ३. विशेषा मूलं for (विशेषान्मूल)

(च) २. ग्रासोनैक्योद्धतौ for (ग्रासोनैक्योद्धतौ)

४३. (घ) १. शरद्वयभक्ते (ग) (च) (ङ) for (शरस्यभक्ते)

२. कृत्तिशर (ग) (ङ) for (कृन्तिशर) ३. युते (ग) (च) for (युतौ)

४. ग्रासाद्यदुनं (ग) ह्यदनंतत् for (ग्रासद्यदुनं)

५. +क्षेत्र व्यवहारः समाप्तः+

(ग) ६. पले for (फले) ७. व्यासो for (व्यासौ)

८. पलयो for (फलयो) ९. ग्रासो (ङ) for (ग्रासौ)

(च) २. कृत्ति for (कृन्ति) ४. ग्रासाद्यदुनं for (ग्रासद्यदुनं)

(ङ) ६. युते for (फले) ३. फले for (युतौ)

४. ग्रासोनैक्यं for (ग्रासद्यदुनं)

क्षेत्रव्यवक्षेत्रफलं वेधगुणं समाखातफलहृतं त्रिभिः शून्या ।
 मुखतुल्यतुल्यभुजैक्यानेकाग्रहृतानि समरस्त्रः ॥ ४४ ॥
 मुखतुल्ययुतिः दलगुणितं वेधगुणं व्यासहारिकं गणितम् ।
 मुखतलगुणं क्वाद्धं वेधेन गणितमौच्चम् ॥ ४५ ॥
 उद्वगणिताद्विशोध्य व्यवहारफलं त्रिभिर्भजेच्छेदम् ।
 लब्धं व्यवहारफले प्रक्षिप्य फलं भवति सूक्ष्मं ॥ ४६ ॥

४४. (घ) १. + अथ खातः + २. ('क्षेत्र व्यव'—यहाँ लुप्त है) २. (ग) + क्षेत्रव्यवहारः +
 ३. हृतं (ग) for (हृतं) ४. शून्याः (ग) सूच्याः for (शून्या)
 ५. मुखतुल (ग) मुखतुल (च) for (मुखतुल्य)
 ६. न्येका (ग) न्यैकाग्र for (नेकाग्र)
 ७. समरज्जुः (ग) (ङ) for (समरस्त्रः)
 (ग) ८. फलं (च) (ङ) for (फल)
 (च) २. क्षेत्रे व्यवहारः समाप्तः, अथ खातः for (क्षेत्रव्यव)
 ४. शून्याः for (शून्या) ६. न्यैकाग्रहृतानि for (नेकाग्रहृतानि)
 ७. समरस्त्रः for (समरस्त्रः)
 (ङ) २. 'क्षेत्रव्यव' लुप्त ४. सूच्याः for (शून्या)
 ५. मुखतलतुल्य for (मुखतुल्यतुल्य)
 ४५. (घ) १. तल (ग) मुखतलयुति (च) for (मुखतुल्ययुतिः)
 २. गणितं (ङ) for (गुणितं)
 ३. व्यावहारिकं (ग) (च) (ङ) for (व्यासहारिकं)
 ४. गणितैक्याद्धं (ग) मुखवगतैक्याद्धं for (गुणैक्याद्धं)
 ५. मौद्रम् (ङम्) (ग) मौत्र for (मौच्चम्)
 (ग) ६. गुणम् for (गणित)
 (च) १. मुखतलयुति for (मुखतुल्ययुतिः)
 ४. गणितैक्याद्धं (ङ) for (गुणैक्याद्धं) ५. मौद्रम् for (मौच्चम्)
 (ङ) १. मुखतलयुति for (मुखतुल्ययुतिः)
 ६. + स्याद् + ५ मौत्रम् for (मौच्चम्)
 ४६. (घ) १. छेषम् (ग) छेषम् for (छेशम्)
 (ग) २. औद्र for (उद्र)
 (च) २. तुद्र for (उद्र) १. छेषं for (छेशम्)
 (ङ) २. औत्र for (उद्र) ३. भजेत् त्रिभिः शेषम् for (त्रिभिर्भजेच्छेदम्)
 ४. भवति फलं सूक्ष्मम् for (फलं भवति सूक्ष्मम्)

खात^१ व्यवहारश्चतुर्थः

आकृतिफलमौव्याहतमग्रतलैक्यार्द्धमौच्यदैर्घ्यगुणम् ।

घनगुणितमिष्टकाघनफलेन हृतमिष्टकागणितम् ॥ ४७ ॥

चितिव्यवहारः समाप्तः ॥

विस्तारायांमांगुलघातो मार्गाहतो द्विवेदहृतः ।

किष्कं गुलग्निलब्धं तत्पणवतिर्भवति कर्मः ॥ ४८ ॥

४७. (घ) १. ख्याव्यवहार (ग) श्रो खातव्यवहारश्चतुर्थः for (खातव्यवहारश्चतुर्थः)
 २. मौच्य (ग) मौव्य for (मौच्य)
 ३. दैर्घ्य for (दैर्घ्य) ४. गुणाः (च) for (गुणम्)
 ५. गणित (ग) (च) (ङ) for (गुणित) ६. हृत (ग) (च) (ङ) for (हृत्)

(ग) ७. चितिव्यवहारः for (चितिव्यवहारः)

(च) १. ख्याव्यवहारश्चतुर्थः for (खातव्यवहारश्चतुर्थः)

(ङ) १. “खात—चतुर्थः” लुप्त ७. मौच्यहृत for (मौव्याहत)

२. मौच्य for (मौच्य) ७. इति चितिव्यवहारः for (चितिव्यवहारः समाप्तः)

४८. (घ) १. विस्ताराया for (विस्तारायां)
 २. मार्गाहतो (ग) मार्गाहतो for (मार्गाहतो)
 ३. द्विवेदहृतः (ग) द्विवेदहृतः (च) (ङ) for (द्विवेदहृतः)
 ४. किष्कं (ग) (च) for (किष्कं)
 ५. गुलानि (ग) (च) (ङ) for (गुलग्निलब्धं) ६. कर्मः (ग) for (कर्मः)

(ग) ७. विस्तारायामंगुल for (विस्तारायांमांगुल)

(च) ७. विस्ताराया for (विस्तारायां) ६. कर्म (ङ) for (कर्मः)

(ङ) ७. विस्तारायामाङ्गुल for (विस्तारायांमांगुल)

८. पणवति for (पणवति)

शाकादिषु^२ शाल्मल्यां^१ शतद्वयं^३ जीवके^४ शतं^५ विशं^६ शालः ।

सरलादिषु^२ सर्वविहगरू^३सु चतुः^४ षष्टिः ॥ ४९ ॥

क्रवच^५ व्ययहार समाप्तः ।

नवमं^१ सूकिषु^२ दशमस्थूले^३ द्वेकादशो^४ भवत्यणुषु ।

परिधेर्वेधपरिधिः^५ षडंशवर्गो^६ हतो^७ गणितम् ॥ ५० ॥

द्विचतुः^१ सत्र्यंशगुणो^२ मित्यंतर^३ बाह्यकोणगः ।

परिधिः^४ प्राग्वत्कृत्वा^५ गणितं^६ तद् गणितं^७ स्वगुणकारहृतं^८ ॥ ५१ ॥

राशिव्यवहारः समाप्तः ।

४९. (घ) १. शालाल्पांश for (शाल्मल्यांश)

२. सरलादिषुशतं सर्वं (ग) for (सरलादिषुसर्वं)

३. विदारूषु (ग) विवहारूषु for (विहगरूषु)

(ग) ४. बीजकेन for (जीवके)

५. यहां 'विशं' पर श्लोकार्ध समाप्त करके 'शाल' से दूसरी पंक्ति आरम्भ है ।

(ङ) ६. क्रकचव्यवहारः (च) for (क्रवचव्यवहार)

(च) ५. वीशंशालः for (विशंशालः) २. + शतं +

३. विदारूषु for (विहगरूषु)

(ङ) ५. विशं for (विशंशालः) २. ३. शतमथाविदारूषु for (सर्वविहगरूषु)

६. लुप्त ।

५०. (घ) १. नवमं सूकिषु (ग) नवमः सूकिषु for (नवमसूकिषु)

२. दशमः (ग) (ङ) for (दशम) ३. वर्गाहतो (ग) वर्गाहतो for (वर्गोहतो)

(ग) ४. परिधेर्वेधः (च) (ङ) for (परिधेर्वेधः)

(च) १. नवमसूकिषु for (नवमसूकिषु) ३. वर्गाहतो (ङ) for (वर्गोहतो)

(ङ) १. नवमः सूकिषु for (नवमसूकिषु) ५. परिधेः for (परिधिः)

५१. (घ) १. मित्यंतर (ग) (च) for (मित्यंतर)

२. परिधिः (यह शब्द पहली पंक्ति का अन्तिम शब्द है) (ङ)

३. हृतम् (ग) (च) (ङ) for (हृतं)

(ङ) १. मित्यन्तर् for (मित्यंतर)

४. इति राशिव्यवहारः for (राशिव्यवहारः समाप्तः)

छायांतरसैकहृतं^१ द्युदलं^२ प्रागपरयो^३ द्युगतशेषम् ।
 दिनगतं^४ शेषांशहृतं^५ द्युदलं छायांतरव्येकम् ॥ ५२ ॥
 दीपतलशंकुतलयोरंतरमिष्टप्रमाणशंकुगुणम् ।
 दीपशिखोच्या शंकुं^३ विशोध्य शेषोद्धृतं छाया ॥ ५३ ॥
 छायाप्रांतरगुणिता छाया छायांतरेण भक्ता भूः ।
 भूः शंकुगुणा छाया विभाजिता दीप शिखौच्यम् ॥ ५४ ॥
 छाया व्यवहार समाप्तः
 गुणकार खण्डतुल्यो गुण्यो गोमूत्रिकाकृतो गुणितः ।
 सहितः प्रत्युत्पन्नो गुणकारकभेदतुल्यो वा ॥ ५५ ॥

५२. (घ) १. +अथछाया+ (आरंभिक प्रकरण का नाम)
 २. छायांतरसैकहृतं (ग) (ङ) for (छायांतरसैकहृतं)
 ३. द्युगतशेषम् (ङ) (ग) द्युगशेषम् for (द्युगतशेषम्)
 ४. दिनगत (ग) (च) (ङ) for (दिनगतं)
 ५. हृतं (ग) (च) (ङ) for (हृतं)
 ६. छायांतरव्येकम् (ग) छायांतराव्येकम् for (छायांतरव्येकम्)
 (च) १. +अथछाया+ ७. हृतं for (हृतं)
 ३. द्युगतशेषं for (द्युगतशेषम्)
 (ङ) १. छायांतरव्येकम् for (छायांतरव्येकम्)
 ५३. (घ) १. छंकु (ग) च्यं छं कुं for शंकुं २. दीपोद्धृतं for (शेषोद्धृतं)
 (ग) ३. दीपशिखौ (च) for (दीपशिखौ)
 (च) १. व्याछंकुं for (च्याशंकुं)
 (ङ) ३. शिखौच्याच्छंकुं for (शिखौच्याशंकुं)
 ५४. (घ) १. दीपक (च) for (दीप)
 (ग) २. भक्ता (अतिरिक्त अंकित) ३. छायाव्यवहारः for (छायाव्यवहार)
 (ङ) १. दीपशिखौच्याच्यम् for (दीपशिखौच्यम्)
 ५५. (घ) १. स्वंज for (खण्ड) २. गुण्यो (ग) गुणो for (गुण्यो)
 ३. कृतो (ग) (ङ) for (कृतो)
 ४. प्रत्युत्पन्नौ (ग) प्रत्युत्पन्नो for (प्रत्युत्पन्नो)
 (ग) ५. गुणितः for (गुणितः)
 (ङ) २. गुण्यो for (गुण्यो)

गुण्यो राशिगुणकारराशिनेष्टधिकोनकेन गुणः ।
 गुण्येष्टवधो न यतो गुणकेभ्यधिकोनके कार्यः ॥ ५६ ॥
 छेदेनेष्ट युतोनेना संभाज्यादनष्टमिष्टगुणम् ।
 प्रकृतिस्थछेदहृतं लब्धायुतहीनकमनष्टम् ॥ ५७ ॥
 गुणछेदफलवधो गुणकहतो गुण्यभाजितो गुणकः ।
 छेदो धृतः फलं गुण्यगुणवधः फलहृतः छेदः ॥ ५८ ॥
 गुण्यगुणकारयोः छेदलब्धयो द्वयो द्वयोर्नाशः ।
 तेषां दृश्यो व्यस्तौ कृत्वा तस्थानयो रिष्टौ ॥ ५९ ॥

५६. (घ) १. राशिनेष्टा (ग) (च) (ङ) for (राशिनेष्ट)
 २. युतो (ग) (च) (ङ) for (यतो)
 (ग) ३. गुण्येष्ट for (गुण्येष्ट) ४. गुणिकेभ्य for (गुणकेभ्य)
 (च) ३. गुणेष्ट for (गुण्येष्ट)
 (ङ) ४. गुणकेभ्यधिको for (गुणकेभ्यधिको)
५७. (घ) १. छेदो नष्टयुतो for (छेदेनेष्टयुतो)
 २. नेनाप्तं (ग) (च) (ङ) for (नेनासं)
 ३. हृतं (ग) (च) (ङ) for (हृतं)
 (ग) ४. दिनष्ट for (दनष्ट) ५. लब्धायुतकम् for (लब्धायुतं)
 (ङ) ५. लब्ध्या for (लब्धा)
५८. (घ) १. गुण्य (ग) (ङ) for (गुण)
 २. फलहृतः (ग) फलहृत (च) for (फलहृतः)
 (ग) ३. हृतो for (हतो)
 (ङ) ३. गुणकहतो for (गुणकहतो) ४. धृतः for (धृतः)
 २. फलहृतश्छेदः for (फलहृतः छेदः)
५९. (घ) १. गुणागुण for (गुण्यगुण)
 १. द्वयोर्द्वयोर्नाशः (ग) वा द्वयोर्द्वयोर्नाशः for (द्वयोर्द्वयोर्नाशः)
 (ग) ३. दृश्यो (च) for (दृश्यो) ४. व्यस्तौ for (व्यस्तौ)
 (च) १. विसर्गं लुप्त २. द्वयोर्द्वयोर्नाशः for (द्वयोर्द्वयोर्नाशः)
 ५. तस्थानयो for (तस्थानयौ)
 (ङ) ६. कारयोश्छेद for (कारयोः छेद) ७. लब्धयोर्यदि द्वयो for (लब्धयोर्द्वयो)
 २. द्वयोर्द्वयो for (द्वयो द्वयो) ३. दृश्यौ for (दृश्यो)
 ८. रिष्टौ for (रिष्टौ)

गुण्यं गुणकारं वा गुणये छेदेन भागहरस्य ।

गुण्यगुणकारराश्यो छेदगुणो भागहरश्च ॥ ६० ॥

छेदस्य छेदरूपं कृत्वा न्यदुक्तवत्सर्वम् ।

अपवर्त्यो तुल्यो न छेदगुणौ छेदगुण्यौ वा ॥ ६१ ॥

स्वविकलषष्ठ्यंशगुणं सकलस्त्र्यंशोद्धतो विकलवर्गः ।

प्रश्नेप्यः सकलकृतौ वर्गघातौ द्वित्रितुल्यवधौ ॥ ६२ ॥

राशेखनं द्विगुणं बहुतरगुणमूनकृतियुतं वर्गः ।

राशेरिष्टयुतोनाद्वधः कृतिवैष्टकृतियुक्तः ॥ ६३ ॥

६०. (घ) १. भागहारस्य (ग) (च) (ङ) for (भागहरस्य)
 २. भागहारश्च (ङ) for (भागहरश्च)
 (ग) ३. गुणयो for (गुणये)
 (च) २. भागहारश्च for (भागहरश्च)
 (ङ) ३. गुणयेच्छेदेन for (गुणयेच्छेदेन) ४. राश्योच्छेद for (राश्योच्छेद)
६१. (घ) १. अछेदस्य छेदं (ग) for (छेदस्य छेदरूपं)
 २. अपवर्त्यौ for (अपवर्त्यौ) ३. तुल्येन (ग) for (तुल्येन)
 ४. छेदगुणौ (ग) for (छेदगुणौ)
 (ग) ५. दुक्तवत्सर्वम् (ङ) for (दुक्तवत्सर्वम्) ६. छेदगुण्यौ वा for (छेदगुण्यौ वा)
 (च) ५. न्यदुक्तवत् for (न्यदुक्तवत्) २. अपवर्त्यौ for (अपवर्त्यौ)
 ४. छेदगुणौ for (छेदगुणौ)
 (ङ) १. अछेदस्य for (छेदस्य)
 ३, ४, ६. छेदगुणौ तुल्येनेष्टेन for (तुल्यो न छेदगुणौ छेद)
६२. (घ) १. सकलस्त्रिंशोद्धतो (ग) सकलस्त्रिंशोद्धतो for (सकलस्त्र्यंशोद्धतो)
 २. प्रश्नेप्यः (ग) (च) (ङ) for (प्रश्नेप्यः)
 ३. वर्गघातौ (ग) वर्गघातौ for (वर्गघातौ)
 (ग) ४. वश्यंशगुणः for (षष्ठ्यंशगुणं) ५. वर्गः for (वर्गः)
 (च) १. सकलस्त्रिंशो हतो for (सकलस्त्र्यंशोद्धतो)
 (ङ) ६. गुणः for (गुणं) १. सकलस्त्रिंशोद्धतो for (सकलस्त्र्यंशोद्धतो)
 ३. वर्गघातौ for (वर्गघातौ)
६३. (घ) १. रूनं (ग) (च) (ङ) for (खनं) २. वैष्ट (ग) (च) for (वैष्ट)
 (ग) ३. कृति for (कृति) ४. युतं वर्गः for (युतं वर्गः)
 ५. युक्तः for (युक्तः)
 (च) ३. कृति for (कृति) (ङ) २. कृतिवैष्ट for (कृतिवैष्ट)

इष्टाल्पराशि^१वर्गो युक्तो^२ना वितर^३विकलवर्ग^४भ्याम् ।
 द्विगुणोत्तराशि^१भ्याम् भक्तौ^२ तेनाधिका^३भ्याम् ॥ ६४ ॥
 स्थाना^१न्तरेषु लब्धं^२ येन समं^३ फलयुतो^४नकछेदः ।
 दलित^१कृतियोगान्तरपदमितरो^२ वा फलयुतो^३ नः ॥ ६५ ॥
 दिग्मात्रमेतद^१न्या ज्योत्पत्तौ^२ कुट्टके च कथयिष्ये ।
 संकलितादिष्टा^१र्याः षट्षष्टिर्द्वादशो^२ऽध्यायः ॥ ६६ ॥
 इति^३ ब्रह्मगुप्ते द्वादशो^४ऽध्यायः ।
 इति श्री ब्राह्मस्फुट सिद्धान्ते द्वादशो^५ऽध्यायः ।

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६४. (घ) १. द्विगुणोत्तर (ङ) for (द्विगुणोत्तर)
 २. तेनाधिकोनाभ्याम् (ग) (च) (ङ) for (तेनाधिकाभ्याम्)
 (ग) ३. भक्तो for (भक्तौ)
 (च) १. द्विगुणोत्तर for (द्विगुणोत्तर)
६५. (घ) १. दलितः (ग) (च) (ङ) for (दलित)
 (ग) २. 'समं' यहां अंकित नहीं है ।
 (ङ) ३. युतो नकछेदः for (युतो नकछेदः)
६६. (घ) १. संकलितादिष्टार्याः (ग) for (संकलितादिष्टार्याः)
 २. + ६६ +
 ३. यह पंक्ति इस प्रति में लुप्त है । (ग)
 (ग) ४. दिग्मात्रमेतद^१न्या for (दिग्मात्रमेतद^२न्या)
 (च) ३. 'इति' से 'अध्याय' तक समाप्ति सूचक वाक्य लुप्त ।
 (ङ) ४. दिग्मात्रमेतद^१न्या for (दिग्मात्रमेतद^२न्या)
 १. दिष्टार्या for (दिष्टार्याः)

अथ प्रश्नाध्यायः

त्रयोदशः

तत्र तावन्मध्यगत्युत्तराध्यायः

प्रश्न^१ध्यायान्^३ प्रवक्षामि^४ सोत्तरान्^५ गणकबुद्धिबुद्धिकरान् ।
 यैज्ञा^२तिस्तन्त्रविदामाचार्यो भवति बुद्धिमताम् ॥ १ ॥
 अधिमासकैः^२ सविकलैर्दृष्टैर्युगयातमवमररात्रैर्वा ।
 द्युगणेन वायुगगतयो वेत्ति स कालतंत्रज्ञः ॥ २ ॥
 अवमाति यः सविकलैरधिमासैरधिकमासकानवमैः ।
 ग्रहमिष्टं^१ ताभ्यां वायो वेत्ति स कलतंत्रज्ञः ॥ ३ ॥
 द्युगुणं^२ विनाधिमासावमैर्विनादिन गणेन चन्द्राक्को ।
 ताभ्यां विनास्फुटतिथि यो वेत्ति स कालतंत्रज्ञः ॥ ४ ॥
 इष्टान्मध्यादन्यांस्तिथिमिष्टान्मध्यमाच्छशिग्रहणम् ।
 इष्टाद्रविदुपातै र्यो वेत्ति विना स तंत्रज्ञः ॥ ५ ॥

१. (घ) १. प्रश्नाध्यायान् (ग) प्रश्नाध्यायान् for (प्रश्नध्यायान्)
 २. बुद्धिमत्यम् (ग) बुद्धिमताम् for (बुद्धिमताम्)
 (ग) ३. वक्ष्यामि for (प्रवक्षामि) ४. 'वृद्धि' पद अंकित नहीं है ।
 (च) १. प्रश्नाध्यायान् for (प्रश्नध्यायान्)
२. (घ) १. वायुगगं (ग) वायुगगतं for (वायुगगत)
 (ग) २. अधिमासकैः for (अधिमासकैः) ३. मवमरात्रैर्वा for (मवमररात्रैर्वा)
 ४. तंत्रज्ञः for (तंत्रज्ञः)
 (च) ३. मवमरात्रैर्वा for (मवमररात्रैर्वा)
३. (घ) १. वेत्ति (च) for (वेत्ति)
 २. कालतंत्रज्ञः (ग) सकलतंत्रज्ञः for (सकलतंत्रज्ञः)
 (ग) ३. अवमानि for (अवमाति) ४. 'यः' पद यहाँ अंकित नहीं है ।
 (च) २. सकालतंत्रज्ञः for (सकलतंत्रज्ञः)
४. (घ) १. द्युगुणं (ग) (च) for (द्युगुणं)
 (ग) २. 'विना' अंकित नहीं ३. 'सकाल' अंकित नहीं
५. (घ) १. रवीन्दू (ग) for (रविन्दु) २. यो for (यों)
 (ग) ३. दन्यास्तिथि for (दन्यांस्तिथि)
 ४. 'विनास' पद अंकित नहीं । इसके स्थान में यहाँ 'सकल' अंकित है ।
 सकल for (विनास)

त्रिगुणः शनिरिन्दुनोन्यभगणलब्धैर्ग्रहादिभिः सहितः ।

भौमोऽर्कोगुरुरिन्दुच्चं वान्यभगणाः के ॥ ६ ॥

द्वित्रिगुणयो रविद्वोर्युति कुजोनान्यभगणलब्धेन ।

राश्यादिनाधिकगुरूरुना शशिरन्यभगणाः के ॥ ७ ॥

द्रष्टोदयिकानश्विन्यौ दयिकात्वाकरो तिथौ मध्यात् ।

मध्यार्कं गुणकं गुणमिष्टं मध्यं स तंत्रज्ञः ॥ ८ ॥

पातोत्तुल्योमगतीन् प्रतिलोमगतीन् ।

ग्रहान् दिवसं वारं विपरीतैः शन्याद्यैर्वैत्ति स कालतंत्रज्ञः ॥ ९ ॥

६. (घ) १. रिन्दुनोन्य (ग) रिन्दूनोन्य for (रिन्दुनोन्य)

२. ग्रहादिभिः (ग) for (ग्रहादिभिः)

३. भौमो हीनोर्का (ग) भौमो हीनोर्को for (भौमोर्को)

४. वाऽन्यभगणाः for (वान्यभगणाः)

(ग) ५. रिन्दुच्चं for (रिन्दुच्चं)

(च) ३. भौमोर्को for (भौमोऽर्को)

७. (घ) १. रवीद्वोर्युतिः (ग) रवीद्वोर्युतिः (च) for (रविद्वोर्युतिः)

२. नाधिका (ग) for (नाधिक) ३. शनि (ग) for (शशि)

(च) ३. शनि for (शशि)

८. (घ) १. इष्टौ (ग) for (द्रष्टौ)

२. यो (ग) (च) for (ी)

(ग) ३. दयिकोनश्विन्यौ for (दयिकानश्विन्यौ)

४. दयिको न वा for (दयिकात्वा)

(च) १. इष्टोदयिका for (द्रष्टोदयिका) ५. मध्यार्कं for (मध्यार्क)

६. गुणमिष्टं for (गुणमिष्टं)

९. (घ) १. पाताननु लोमगतीन् (ग) पाताननु लोमगतीन् for (पातोत्तुल्योमगतीन्)

२. दिवस (ग) for (दिवसं)

(च) १. पातोत्तुलो for (पातोत्तुल्यो)

३. वैत्ति for (वैत्ति)

ध्यतिपात^३वैधृत^२बृहस्पतिवर्षस्वोच्चनीचपरिवर्तनात् ।
 द्विग्रहयोगाश्च युगे यो वेत्ति स कालतंत्रज्ञः ॥ १० ॥
 सावनमासाब्दाधिप होरेशानिष्टमध्यसंयोगात् ।
 इष्टगुणितैर्युतोना दिष्टान्यो वेत्ति गणकः सः ॥ ११ ॥
 युगरविदिवसैर्गुणिता गताधिमासाः स्वशेषसंयुक्ता ।
 भक्ता युगाधिमासैः फलं युगादेर्गता दिवसाः ॥ १२ ॥
 गुणितानि चन्द्रदिवसैर्गतावमानि स्वशेषसहितानि ।
 विभजेद्युगावमैः फलमनष्टमधिमासकैर्गणितम् ॥ १३ ॥
 हूतमिदुर्दिनैर्लब्धाधिमासदिवसैर्विहितकमनष्टम् ।
 युगयातदिनान्यधिमासदिनगणेष्वष्टग्रहाद्यमतः ॥ १४ ॥
 द्युगुणैर्दुदिवसघातात् कुदिनाप्तमधोयुगादिमासगणम् ।
 युगशशिदिनभक्तं फलमासदिनोत्तं युगगतदिनानि ॥ १५ ॥

१०. (घ) १. परिवर्त्तात् (ग) परिवर्त्तान् for (परिवर्त्तनात्)
 २. योगाश्च (च) for (योगाश्च)
 (ग) ३. व्यतिपात for (व्यतिपात) ४. सकलतंत्रज्ञः for (सकालतंत्रज्ञः)
 (च) १. परिवर्त्तान् for (परिवर्त्तनात्)
११. (ग) १. गुणिति for (गुणितै)
१२. (घ) १. गुणिताधिमासाः for (गुणितागताधिमासाः)
 २. संयुक्ताः (ग) (च) for (संयुक्ता)
 (च) १. गुणिता for (गुणिता)
१३. (घ) १. मानिः for (मानि)
 २. गुणिता (ग) गुणितम् for (गुणितम्)
 (च) २. गुणितं for (गुणितम्)
१४. (घ) १. हूत (ग) (च) for (हूत) २. लब्धा for (लब्धा)
 ३. विहीन (च) for (विहित) ४. दिनाऽन्यधि for (दिनान्यधि)
 (ग) ५. मिदु for (मिदु) ६. ग्रहाद्यमतः for (ग्रहाद्यमत)
१५. (घ) १. गणैर्दु (ग) (च) for (गुणैर्दु)
 (ग) २. कुदिनाप्तं for (कुदिनाप्त) ३. मधोर्यु for (मधोर्यु)
 ४. गुणम् for (गणम्)
 (च) ४. युगाधिमासगणं for (युगादिमासगणम्)

गुणमधिमासकशेषं युगकुदिनैः खमशेषमधिमासैः ।
 तद्युतिरिदुदिनहूताधिमासशेषं स्फुटं भवति ॥ १६ ॥
 कुदिनगताधिकमासकघातः स्पष्टाधिमासशेषयुतः
 भक्तो युगाधिमासैरह्णाणिः पूर्ववन्मध्याः ॥ १७ ॥
 भूदिनगता इवमवधः शेषयुक्तो युगावमविभक्तः ।
 लब्धं भवति द्युगुणो युगयातो मध्यमाः प्राग्वत् ॥ १८ ॥
 युगतराशिमासवधाद्रविमासाप्तं दिनाकृतिं सदिनम् ।
 भूदिनगुणशशिदिनहूतपाप्तमहर्गणः सैकम् ॥ १९ ॥

१६. (घ) १. दित for (दिन) २. हूताधि (च) for (हूताधिमास)
 (ग) ३. शेषस्फुटं for (शेषं स्फुटं)

१७. (ग) १. 'क' अंकित नहीं
 २. मासरहर्गणः for (मासैरह्णाणिः)
 ३. पूर्ववत् मध्या for (पूर्ववन्मध्या)
 (च) २. युगाधिमासैरहर्गणः for (युगाधिमासै रह्णाणिः)

१८. (ग) १. वधः स्वशेष for (वधः शेष)
 २. द्युगुणो (ग) (च) for (द्युगुणो)
 (ग) ३. मध्यमा for (मध्यमाः)
 (च) १. + स्व +

१९. (घ) १. युगतराशि (ग) युगतराशि for (युगतराशि)
 २. दिनीकृतं (ग) (च) for (दिनाकृतं)
 ३. गुणं for (गुण)
 ४. शशिदिनैहूता (ग) शशिदिनहूत for (शशिदिनहूत)
 ५. मासमहर्गणः (ग) मासमहर्गणः for (पाप्तमहर्गणः)
 ६. सैकम् (ग) (च) for (सैकम्)

(ग) ७. मासास्त for (मासाप्तं)

(च) ५. मासमहर्गणाः for (पाप्तमहर्गणः)
 ४. दिनहूत for (दिनहूत)

गतदिवसा^१ पृथक् विमासक^२ गुणिता^३ रविदिनाप्तमासदिनैः सहिता^४ ।
पृथग्वमगुणा^५ शशिविमासोत्तनकाकपरणः ॥ २० ॥

गुणिताद्यु^६ गाधिमासैर्युगभू^७ दिवसैर्ह^८ तादवमशेषात् ।
फलयुक्तमधिकमासकशेषं मध्यावतोऽक्क^९दू ॥ २१ ॥
अधिमासोवमशेषयुगशशिमूहते^{१०} पृथग्लब्धे^{११}
मासदिनाद्ये^{१२} स्याप्ये गतमासदिनानि^{१३} चैत्राद्यैः ॥ २२ ॥
अवमावशेषलब्धा^{१४} सहितानि^{१५} पृथक् त्रयोदशगुणानि^{१६} ।
अधिमास^{१७} शेषलब्धा^{१८} हीनानि^{१९} पृथग् रविशशांकौ ॥ २३ ॥

२०. (घ) १. पृथग्विमासकगुणिता (ग) पृथग्विमासकगुणिता for (पृथक् विमासक-
गुणिता)
२. सहिता: (ग) for (सहिता)
वि० यह दूसरी पंक्ति का आरंभिक शब्द है
३. पृथग्वमगुणा: (ग) for (पृथग्वमगुणा)
४. द्युपरण: for (कपरण:)
- (ग) ५. गतदिवसा: for (गतदिवसा)
६. दिनसाप्तोत्तनकाकपरणः ॥ २० ॥ for (दिवसाप्तोत्तनकाकपरणः)
- (च) १. पृथग्विमासक for (पृथक् विमासक)
७. मासदिनैः सहिता: for (मासदिनैः सहिता)
३. पृथग् वमगुणा: for (पृथग्वमगुणा) ४. काकपरण: for (काकपरण:)
२१. (घ) १. अक्कंदु: for (अक्कंदू)
(ग) २. (भू) अंकित नहीं २. ह^८ ता for (ह^८ ता)
४. फलयुक्तं मधिमसाशेषं for (फलयुक्तमधिकमासकशेषं)
- (च) ३. ह^८ ता for (ह^८ ता) १. मध्यावतोऽक्क^९दू for (मध्यावतोऽक्क^९दू)
२२. (घ) १. शेषे (ग) for (शेष)
२. भूदिनहृते (ग) भूदिनहृता for (भूहृते)
(ग) ३. मधिमसावम for (अधिमासोवम)
४. चैत्रदै for (चैत्राद्यैः)
(च) २. +दि+
२३. (घ) १. हीनातिपृथग् for (हीनानि पृथग्)
(ग) २. लब्धा: for (लब्धा) ३. सहिता for (सहितानि)
४. त्रयोदश for (त्रयोदश) ५. गुणास्तेन for (गुणानि)
६. शशिकौ for (शशांकौ)

गतमासदिनावशेषलब्धयोगाः त्रयोदशगुणाञ्च ॥
 अधिमासशेषलब्धवारविचन्द्रोच्चै युते शोध्ये ॥ २४ ॥
 केन्द्रे पृथक् फले द्वादशोद्धृते न्यस्तमृणधनं सौरम् ।
 अनुलोममैदवं मासदिनावमशेषलब्धयुतौ ॥ २५ ॥
 तिथिविकलषष्टिघाताद्रविहृतभुक्तचंतराप्तघटिकासु ।
 देशांतरमनुलोमं भुजांतरं चार्कं फलमसदः ॥ २६ ॥
 अवमविकलं न सावनमेभिः परिकल्पितं यतश्चांद्रम् ।
 नार्थभटाद्यैः प्रश्नो मध्यान्यत्वा कृतो ज्ञातः ॥ २७ ॥
 ज्ञातभुगणादिभुक्तं सविकलमिष्टं युगभगणसंगुणितम् ।
 ज्ञातयुगभगणभक्तं मध्योभगणादिफलमिष्टः ॥ २८ ॥

२४. (घ) १. चन्द्रोच्चै for (चन्द्रोच्चै)
 (ग) २. दिनावमशेष for (दिनावशेष)
 ३. योगा for (योगाः) ४. त्रयोदश for (त्रयोदश)
 (च) ४. त्रयोदश for (त्रयोदश)
२५. (घ) १. मैदवं (ग) मैवं for (मैदवं)
 २. लब्धयुतो for (लब्धयुतौ)
 (ग) ३. केन्द्र for (केन्द्रे) ४. प्रथक् for (पृथक्)
 ५. बस्तमृण for (न्यस्तमृण)
२६. (ग) १. 'ष्टि' for (षष्टि)
 २. द्रविहृत for (द्रविहृत) ३. भुक्तांतराप्त for (भुक्तचंतराप्त)
 ४. घटीकासु for (घटिकासु) ५. मनुलोमौ for (मनुलोमं)
 ६. भुजांतर for (भुजांतरं) ७. वासर्क for (चार्कं)
 (च) २. द्रविहृत for (द्रविहृत)
 ७. चार्क for (चार्कं)
२७. (घ) १. कृतोज्ञातः for (कृतोज्ञातः)
 (ग) २. यतश्चांद्र for (यतश्चांद्रम्) ३. प्रश्नो for (प्रश्नो)
२८. (घ) १. भगणादि (ग) (च) for (भुगणादि) २. मिष्टम् for (मिष्ट)
 (वि०)—इस श्लोक की दोनों पंक्तियों के मध्य में निम्नांकित तीसरी पंक्ति भी दी गई है—
 “ज्ञात युगभगणादिभुक्तं सविकलमिष्टं युग भगण संगुणितम्”
 (ग) ३. संगुणितम् for (संगुणितम्)

इष्टाहृतभक्तानां ध्व्यादीनां संयुतेर्द्वयोरथवा ।
 इष्टगुणकारगुणयोर्विभक्तयोर्वांतरादथवा ॥ २६ ॥
 ज्ञानैकभगणभुक्तिस्तद्भगमाप्तं यदिष्टभगणेभ्यः ।
 भगणदिवसविकलं सविकलेष्टभगणादि गुणमिष्ट ॥ ३० ॥
 शशिदिनगुणं सविकलं वद्भुक्तं मंडलादितद्गुणैः ।
 विभेजफलं सविकलास्थितयः प्रागवत् स्फुटीकरणम् ॥ ३१ ॥
 पातेंदुयोगलब्धौ कृत्वा देशांतराद्यमनुलोमम् ।
 विक्षेपो स्यात्सूर्यादिभिर्विनेदुग्रहणमेवम् ॥ ३२ ॥
 कुदिनदुतमवशेषं द्वादशभिर्गुणितं मासमशद्यम् ।
 द्वादशगुणतिथ्यंशैर्युतं धनं भास्करे चंद्रः ॥ ३३ ॥

२६. (घ) १. नांछादीनां (ग) नां द्वाद्यादीनां for (ध्व्यादीनां)
 (ग) २. वांतरदथवा for (वांतरादथवा)
 (च) १. द्वाद्यादीनां for (ध्व्यादीनां)
३०. (घ) १. ज्ञानैक (च) for (ज्ञानैक)
 २. भाप्तं (च) for (माप्त)
 ३. भगणादिसविकलं for (भगणदिवसविकलं)
 (ग) ४. भगणस्तद्भगणात् for (भगणभुक्ति) ५. यं for (य)
 ६. भगणादि दिसविकलं for (भगणदिवसविकलं)
 ७. गुणमिष्टम् for (गुणमिष्ट)
 (च) ६. भगणा for (भगण)
३१. (घ) १. विभजेत्फलं (च) for (विभेजफलं)
 (ग) २. यद्भुक्तं for (वद्भुक्तं)
 ३. स्थितयः (च) for (स्थितयः)
३२. (घ) १. विक्षेपोस्मात् (ग)(च) for (विक्षेपोस्यात्)
 (च) २. कृत्वा for (कृत्वा)
३३. (घ) १. हृत for (दुत) २. माप्त (ग) (च) for (मास)
 (ग) ३. मवमशेषं for (मवशेषं) ४. गुणित for (गुणितं)
 ५. मंशाद्यम् for (मशद्यम्) (च)
 (च) १. हृत for (दुत)

द्युगुणं युगाधिसासैर्गुणितं युगभूदिनैर्भजेत्लब्धम् ।
 भगणादिमध्यमाकंस्थोदश गुणाधिकश्चन्द्रः ॥ ३४ ॥
 इष्टगुणकारगुणितं ग्रहभगणैर्व्यांतरं यथा निहितम् ।
 कृत्वा कुदिनैर्विभजे छेषो न युतानि कुदिनानि ॥ ३५ ॥
 अघनभगणलब्धं घनर्णमिष्टग्रहस्य युगभगणैः ।
 अन्यफलमृणधनं चेद्भूतान्यन्ययुगभगणाः ॥ ३६ ॥
 भदिनानि ग्रहभगणैरुक्तानि भवन्ति सावनदिनानि ।
 इष्टादिवन्योदयिकाः स्वसावनैः पूर्ववन्मध्याः ॥ ३७ ॥
 रविभगणाप्तं दिसविकलं ज्ञेयमंडलेभ्यो यत् ।
 मध्यार्कसविकलकलासंगुणितं ज्ञेयमध्यमकलाः ॥ ३८ ॥

३४. (घ) १. द्युगुणं (ग) द्युगुणं for (द्युगुणं) २. भोजल्लब्धम् for (भजेत्लब्धम्)
 ३. मध्यमाकंस्थोदश (ग) for (मध्यमाकंस्थोदश)
 ४. गुणाधि चेंदुः (ग) गुणाधिकं चन्द्रः for (गुणाधिकश्चन्द्रः)
 (ग) ५. भूदिनै (च) for (भूदिनै)
 (च) १. द्युगुणं for (द्युगुणं) ३. मध्यमाकंस्थोदश for (मध्यमाकंस्थोदश)
 ४. गुणाधिकश्चेंदुः for (गुणाधिकश्चन्द्रः)
३५. (घ) १. गुणित for (गुणितं)
 २. छेषोऽनयुतानि for (छेषो न युतानि)
 (ग) ३. व्यांतरं for (व्यांतरं)
 ४. निहितम् for (निहितम्)
 ५. विभजेत् छेषो for (विभजे छेषो)
 (च) ६. कृत्वा for (कृत्वा)
३६. (घ) १. यन्न्य (ग) for (अघन) २. घनर्ण (ग) for (घनर्ण)
 (च) १. अघ for (अघ) २. घनर्थ for (घनर्ण)
३७. (घ) १. इष्टादिवन्योदयिकाः (ग) for (इष्टादिवन्योदयिकाः)
 (ग) २. सवनदिनानि for (सावनदिनानि)
३८. (घ) १. रविभगणाप्तलिप्तादि for (रविभगणाप्तम्)
 (ग) २. मध्यकलाः for (मध्यमकलाः)
 (च) ३. मध्यार्क for (मध्यार्क)

इष्टभगोन^१ भूदिनशेषैर्भगणैः क्रतो मध्यः ।
 अनुलोगमगो विलोमो भवति विलोमोनुलोगमतिः ॥ ३६ ॥
 द्युगुणेन^२ कुदिनशेषैरनुलोमगो विलोममतिः ।
 भवति विलोमो मध्योरनुलोमगो वाकृतः प्राग्वत् ॥ ४० ॥
 कल्पदिनसप्तकवधात् कल्पगताहर्गणोनकष्टेषात् ।
 सप्तहृता^३ दिनवारः शेषं शन्यादिको भवति ॥ ४१ ॥
 व्यतिपात^४ वैधृतान्यर्कं चंद्रभगणयुताद्विसंगुणिता^५ ।
 गुरुवर्षाण्याश्चा युजा द्वादशगुणिताः गुरोर्भगणाः ॥ ४२ ॥
 स्वोच्चग्रहयुगभगणा विशेषितास्वोच्चनीचपरिवर्ताः ।
 भगणांतरं विद्योगा कार्यास्त्रैराशिकेन गताः ॥ ४३ ॥

३६. (घ) १. इष्टभगणोन (ग) (च) for (इष्टभगोन)
 २. क्रतोग्रहो मध्यः for (क्रतोमध्यः)
 ३. लोमोनुलोगमतिः (ग) विलोमोनुलोगमतिः for (विलोमोनुलोगमतिः)
 (च) २. क्रतो ग्रहोमध्या for (क्रतोमध्यः)
४०. (घ) १. द्युगुणेन (ग) (च) for (द्युगुणेन)
 २. मध्योनुलोमगो (ग) मध्योनुलोमगो for (मध्योरनुलोमगो)
 (ग) ३. शेषैर्भगणै for (शेषैरनुलोमगो) ४. प्राग्वत् for (प्राग्वत्)
 (च) २. मध्योनुलोमगो for (मध्योरनुलोमगो)
४१. (घ) १. सप्तहृतादिनवारः (ग) सप्तहृतादिनवारः for (सप्तहृतादिनवारः)
 (ग) २. हर्गणो for (हर्गणो) ३. शेषः for (शेषः)
 (च) १. सप्तहृतादिनवारः for (सप्तहृतादिनवारः)
४२. (घ) १. संगुणिताः (ग) (च) for (संगुणिताः)
 २. गुणिता गुरोर्भगणाः (ग) for (गुणिताः)
 (ग) ३. व्यतिपात for (व्यतिपात) ४. भगणा for (भगणा)
 (च) ५. वैधृतान्यर्क for (वैधृतान्यर्क) २. गुणिता for (गुणिताः)
४३. (घ) १. द्वियोगाः (ग) (च) द्वियोगा for (वियोगा)
 (ग) २. विशेषिताः for (विशेषिता)

द्युगुणास्त्रिंशद् भक्ताद्यलब्धं^२ द्विगुणितं^३ सरूपं^४ तत् ।
 सप्तविभक्तं^१ शेषः सावनमासाधिपोर्कादि ॥ ४४ ॥
 षष्टिशतत्रयभक्तात् कल्पगताहर्गणात्फलं^२ त्रिगुणम् ।
 सैकं^३ सप्तविभक्तं^४ सायनवर्षाधिपोर्कादि ॥ ४५ ॥
 अर्कोनलग्नहोरा^१ पंच गुणाः सविकलाः यदि सरूपाः ।
 सप्तविभक्ता शेषो दिनाधिपात् कालहोरेणः ॥ ४६ ॥
 त्रिचनुरनंतरं षष्टयः^१ सावनमासाब्ददिनसहोरेणः ।
 दिनगतघटिका द्विगुणा^२ पंच हुताश्रान्यमतमेतत् ॥ ४७ ॥
 गच्छधनमिष्टं गुणितैर्धनैर्युतो न^३ पृथक् पृथक्^४ सहितम् ।
 गुणक युतो न पदहृत सर्वधनमतोवशेषाणि ॥ ४८ ॥

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४४. (घ) १. द्युगुणास्त्रिंशद् (ग) (च) for (द्युगुणास्त्रिंशद्)
 २. यल्लब्धं (ग) भक्तात् यल्लब्धं for (भक्ताद्यलब्धं)
 ३. ङ्कादिः for (कादि)
 (ग) ४. सरूप for (सरूपं)
 (च) २. भक्ताद्यलब्धं for (भक्ताद्यलब्धं) ३. ङ्कादिः for (कादि)
४५. (घ) १. कादिः for (कादि)
 (ग) २. हर्गणा for (हर्गणा) ३. सैक for (सैकं)
 (च) १. ङ्कादिः for (कादि)
४६. (घ) १. सप्तविभक्ताः (ग) (च) for (सप्तविभक्ता)
 (ग) २. होराः (च) for (होरा) ३. सविकला for (सविकलाः)
 ४. दिनपाद्यः काल for (दिनाधिपात् काल)
 (च) ५. अर्कोन for (अर्कोन)
४७. (घ) १. षष्ट्याः (ग) (च) for (षष्टयः) २. दिवस(ग) for (दिनस)
 ३. द्विगुणाः (ग) (च) for (द्विगुणा)
 (च) २. मासाब्ददिवसहोरे रेशाः for (मासाब्ददिनसहोरेणः)
४८. (ग) १. गुणितै for (गुणितैः) २. हृतं for (हृत)
 (च) ३. शेषाणि for (शेषाणि)

मध्योत्तरमेकोनार्याः पंचाशत्त्रयोदशोऽध्यायः ।

ज्ञात्वेनं तंत्रविदामाचार्यो भवति मध्यगतौ ॥ ४६ ॥

इति त्रयोदशोऽध्यायः

इति ब्राह्मस्फुटसिद्धान्ते मध्यगतिप्रश्नोत्तराध्यायः

त्रयोदशः ।

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- ४६ (घ) १. पंचाशत्त्रयोदशोऽध्यायः (ग) पंचाशत्त्रयोदशोऽध्यायः for (पंचाशत्त्रयोदशोऽध्यायः)
(ग) २. नार्या for (नार्याः)
३. 'इति' से 'अध्यायः' तक अंकित नहीं, केवल समाप्तिसूचक ॥ छः ॥ ॥ छः ॥
॥ छः ॥ अंकित है ।
- (च) १. पंचाशत्त्रयोदशोऽध्यायः for (पंचाशत्त्रयोदशोऽध्यायः)
३. 'इति' से 'अध्यायः' तक लुप्त.

अथ स्फुटगत्युत्तराध्यायः

चतुर्दशः

भुजभागः कोटिज्यां कोट्यं शैर् यः करोति बाहुज्याम् ।
 कोटि^३ भुजेन बाहुं^४ क्योस्त्रावा स्फुट^५गतिज्ञः सः ॥ १ ॥
 परमफलकेन्द्रविकः करोति कोटिछया स्फुटं^५ कर्णम् ।
 कर्णात्कोटिकोद्या बाहुं^४ वा स्फुट^५गतिज्ञः सः ॥ २ ॥
 केन्द्रभुजकोटिजीवा परमफलज्ञः करोति यः कर्णम् ।
 स्वोच्चं^३ स्वफलस्पष्टं करोति यः स्फुट^५गतिज्ञः सः ॥ ३ ॥
 द्युगुणस्फुटग्रहयो भुजकोटिज्ये फले विना ज्याभिः ।
 ज्याभिर्विना फलधनुः करोति वा स्फुट^५गतिज्ञः ॥ ४ ॥
 इष्टदिवन्योदयिकान् करोति यो मध्यमान् ग्रहान् स्पष्टान् ।
 स्वोच्चस्फुटग्रहं^३ यः करोति वा स्फुट^५गतिज्ञः सः ॥ ५ ॥

१. (घ) १. कोट्यं शै (ग) (च) for (कोट्यं शै) २. कोद्यावा (ग) (च) for (क्योस्त्रावा)
 (ग) ३. कोटिभुजेन for (कोटिभुजेन) ४. बाहु for (बाहुं)
 (ङ) २. कोट्या वा for (क्योस्त्रा वा) ५. स्फुटगतिज्ञः for (स्फुगतिज्ञः)
 २. (घ) १. विद्युः (ग) वित् यः for (केन्द्रविकः) २. ज्याया (ग) (ङ) for (छया)
 (ग) ३. कोटिम् for (कोटि)
 (च) १. विद्युः for (विकः) ४. कर्णम् for (कर्णम्)
 ३. कर्णात्कोटिकोद्या for (कर्णात्कोटिकोद्या) ५. ज्ञतिज्ञः for (गतिज्ञः)
 (ङ) १. विद्युः for (विकः) ३. कोटिकोट्या for (कोटिकोद्या)
 ३. (च) १. कर्णम् for (कर्ण)
 (ङ) २. सफल for (स्वफल)
 ४. (घ) १. द्युगुणा (ग) सुगुणात् for (द्युगुण) २. ग्रहं (ग) (च) (ङ) for (ग्रह)
 (ग) ३. स्फुटं (ङ) for (स्फुट) ४. + सः + (च) (ङ)
 (च) १. द्युगुणा for (द्युगुण)
 (ङ) १. द्युगुणात् for (द्युगुण)
 ५. (घ) १. इष्टदिवन्योदयिकान् (ग) इष्टदिवन्योदयिकान् for (इष्टदिवन्योदयिकान्)
 २. मध्यमान् स्पष्टान् for (मध्यमान् ग्रहान् स्पष्टान्)
 (घ) ३. स्फुगतिज्ञः for (स्फुटगतिज्ञः)
 (च) १. इष्टदिवन्यो for (इष्टदिवन्यो)
 (ङ) ४. मध्यान् for (मध्यमान्)

संक्रान्तेराद्यंतौ ग्रहस्य यो राशिभूतिथिकरणांतान् ।
 व्यतिपाताद्यंतौ वा यो वेत्ति स्फुटगतज्ञः सः ॥ ६ ॥
 व्यासदलमितरजीवाभुजकोद्यंशो क्रमज्यया हीनम् ।
 कोटिभुजज्या व्यासाद्धकृतिविशेषात्पदं चान्या ॥ ७ ॥
 कोटिज्यया द्विगुणया गुरुरेत्प्रफलज्यता युतोनायाः ।
 मृगकक्चर्चादौ त्रिज्यां तत्फलकृतियुते पदं कर्णः ॥ ८ ॥
 त्रिज्यांत्यफलत्वतियुतेः कर्णकृतेऽचांतरेवशेषं यत् ।
 द्विगुणात्यफलहृतं तत्कोटीज्या बाहुजीवातः ॥ ९ ॥

६. (घ) १. करणान्तात् (ग) (च) for (करणान्तान्)
 (ग) १. राद्यंतो for (राद्यंतौ) ३. तिथिक for (तिथि)
७. (घ) १. ज्ययाहीनाम् (च) for (ज्ययाहीनम्) २. वान्या for (चान्या)
 (ग) ३. कोट्यंशोत्क्रम (च) for (कोद्यंशोत्क्रम)
 (ङ) ३. कोट्यंशोत्क्रम for (कोद्यंशोत्क्रम)
८. (घ) १. गुरुरांत्यफल (ग) (च) for (गुरुरांत्यफल)
 २. ज्यया (ग) (च) for (ज्यता)
 ३. त्रिज्यांत्यफल (ग) for (त्रिज्यां तत्फल) ४. युतेः (ग) (च) for (युतेपदं)
 (च) ६. मृगकक्चर्चादौ for (मृगकक्चर्चादौ) ३. त्रिज्यांत्यफल for (त्रिज्यांत्यफल)
 ५. कर्णः for (कर्णः)
- (ङ) १. सन्त्यफलज्या गुरुरांत्या for (गुरुरांत्यफलज्यता)
 ३. त्रिज्यांत्यफलज्या for (त्रिज्यांत्यफल) ४. युतेः for (युते)
९. (घ) १. त्रिज्यांत्यफलत्वति for (त्रिज्यांत्यफलत्वति)
 २. तत्कोटीज्या (च) (ङ) for (तत्कोटीज्या)
 (ग) ३. कृति for (त्वति) ४. हृतं for (हृतं)
 (च) १. राद्यांत्य for (त्रिज्यांत्य) ३. फलत्वतियुतेः for (फलत्वतियुतेः)
 (ङ) ३. कृतियुतेः for (त्वतियुतेः) ५. तरेऽवशेषं for (नरेवशेषं)
 ६. जीवातः for (जीवातः)

कथनामंडलतुल्यं प्रतिमंडलमध्यमवनिमध्यात्स्वेत् ।
 त्वोच्चनीचवृत्तव्यासाद्धिभिमुखमुच्चास्य ॥ १० ॥
 प्रतिमंडलस्य परिधौ मध्यमभुत्तचा स्फुटग्रहो भ्रमति ।
 मंदोच्चादनुलोमं शीघ्रात्प्रतिलोममवनिस्थाः ॥ ११ ॥
 स्पष्टं पश्यति यस्मात् मध्याद्वनाधिकं स्वकक्षायाम् ।
 तस्मात्तदन्तरफलमृणं धनं धने वा ग्रहे मध्ये ॥ १२ ॥
 ग्रन्थफलज्ययात्स्वान्यदयोराद्यंतयोरूपरिकोटिः ।
 द्वितीयोर्ध्वतोघस्तदंतरैक्यं ततः कोटिः ॥ १३ ॥

१०. (घ) १. कक्षा (ग) (च) (ङ) for (कथना) २. मंलमध्य for (मण्डलमध्य)
 ३. खे (ग) (ङ) for (स्वेत्) ४. तत्त्वोच्चनीच (ग) (ङ) for (त्वोच्चनीच)
 ५. मुच्चस्य (ग) (च) for (मुच्चास्य)
 (ग) ६. तुल्य (ङ) for (तुल्यं)
 (च) ३. त्वेत for (त्वेत्)
 (ङ) ५. अभिमुखमुच्चस्य for (भिमुखमुच्चास्य)
११. (घ) १. भ्रवनिस्थः (ग) for (भ्रवनिस्थाः)
 (ग) २. स्फुटग्रहो for (स्फुटग्रहो)
 (च) १. मवनिस्थः (ङ) for (मवनिस्थाः)
१२. (घ) १. मध्याद्वनाधिकं (ग) (च) (ङ) for (मध्याद्वनादिकं)
 (ग) २. 'धने' लुप्त है, (ङ) ।
 (च) ३. यस्मान् for (यस्मात्) ।
१३. (घ) १. ज्याग्रात्स्यात् (ग) for (ज्ययात्स्वान्)
 २. द्वितृतीययोः (ग) for (द्वितीययो)
 (ग) ३. पदयो for (यदयो) ४. कोटि for (कोटिः)
 (च) १. ग्रन्थ (ल्यु) फलज्याया for (ग्रन्थफलज्यया)
 ३. त्वात्पदयो for (त्स्वान्यदयो)
 (ङ) १. ज्याग्रात् for (ज्यायात्) ३. स्यात्पदयो for (स्वान्यदयो)
 २. द्वितृतीययो for (द्वितीययो) ३. रघस्तात् for (यंतोघस्)

कोद्यांत्यफलाद्यै^२ क्यं मकरादावंतरं^३ कुलिरादौ ।
तद्वाहुज्याकृत्योः संयोगपदं भवति कर्णः^४ ॥१४॥
प्रतिमंडलपदमाद्यं^१ ग्रहत्रयं^२ सांत्यधनुरतो^३न्यच्च ।
चक्रा^४र्द्धातमतोन्यद्याद्यभचक्रांतं^५ मंत्यमतः ॥ १५ ॥
त्रिमनेवांत्यफलधनुर्युतमाद्यं^१ नवमं^२ तृतीयपदमून ।
द्विचतुर्थेषु^३ द्वादशभाग्निप्रतिमंडलपदानि ॥१६॥

१४. (घ) १. कोटद्यंत्य (ग) for (कोद्यांत्य)

२. फलद्यैक्यं (ग) फलज्यैक्यं for (फलाद्यैक्यं)

३. कुलीरादौ (ग) (च) (ङ) for (कुलिरादौ)

(च) १. कोटद्यांत्य फलाद्यैकं for (कोद्यांत्यफलाद्यैकं) ४. कर्णः for (कर्णः)

(ङ) १. कोटद्यन्त्य for (कोद्यांत्य) २. फलज्यैक्यं for (फलाद्यैक्यं)

१५. (घ) १. ग्रहत्रयं (ग) ग्रहत्रयं for (ग्रहत्रयं)

२. रतोऽन्यच्च (ग) रतोऽन्यश्च for (रतोऽन्यच्च)

३. मतोन्यद्वाद्यभ (ग) for (मतोन्यद्याद्यभ)

४. चक्रांतमंत्यमतः (ग) for (चक्रांतमंत्यमतः)

(ग) ५. चक्रार्धत for (चक्रार्द्धांत)

(च) १. ग्रहत्रयं (ङ) for (ग्रहत्रयं)

(ङ) ५. चक्र र्धमनेनोनं द्वितृतीयं चतुर्थमाद्यसमम् for (चक्रार्द्धातमतोन्यद्याद्यभचक्रांतं मंत्यमतः)

१६. (घ) १. त्रिमनेवांत्य for (त्रिमनेवांत्य) २. नवममम् for (नवमं)

३. मूनम् (ङ) for (मून) ४. भाग्नि for (भाग्नि)

(ग) यह श्लोक इस प्रति में नहीं है ।

(च) १. त्रिमनेवांत्य for (त्रिमनेवांत्य) ४. द्वादशभाग्नि for (द्वादशभाग्नि)

(ङ) १. त्रिमनन्त्य for (त्रिमनेवांत्य) २. नवमं for (नवमं)

४. षड्द्वादशभाग्नि for (षुद्वादशभाग्नि)

कर्णहृते^१ व्यासाद्धं^२ भुजज्यया गुणितमाप्तधनुराद्यैः^३ ।
 प्रोह्यदलाद्वितये षड्राशियुतं तृतीयपदे ॥ १७ ॥
 चक्रत्प्रोह्य चतुर्थे स्फुटोज्ञयोरन्तरं स्वमंदोच्चे^४ क्षेप्यम्^५ ।
 शीघ्रे शोध्यं तत्स्पष्टं^६ पूर्ववच्छेषम्^७ ॥ १८ ॥
 मध्यस्फुटांतरकला बाहुफलं भवति तीक्ष्णकिरणस्य ।
 स्फुटभुत्तथाकर्मादीनां भुजान्तरं क्षयधनं रविवत् ॥ १९ ॥

१७. (घ) १. कर्णहृते (ग) (ङ) for (कर्णहृते) २. राद्यैः (ग) राद्ये for (राद्यैः)
 ३. भदला (ग) (ङ) for (दला)

(ग) (वि० यहां यह श्लोक १६ की संख्या पर अंकित है ।)

४. द्वितीये (ङ) for (द्वितये) ५. षड्राशियुतं for (षड्राशियुतं)

(च) १. हृतं for (हृते) ३. प्राकरभदला for (प्रोह्यदला)

(ङ) २. राद्ये for (राद्यैः)

१८. (घ) १. चक्रत्प्रोह्य (ग) (ङ) for (चक्रत्प्रोह्य)

२. मंदोच्चोत्क्षेप्यम् (ग) for (मंदोच्चे)

(वि० 'मंदोच्चे' पर श्लोकाद्यं समाप्त ।)

३. छेषम् for (वच्छेषम्)

(ग) ४. स्फुटोच्च for (स्फुटोच्चयो)

५. 'क्षेप्य' for (क्षेप्यं)

(वि० इससे द्वितीय पंक्ति का आरम्भ)

६. स्पष्टः (ङ) for (स्पष्टं)

(वि० इसकी श्लोक संख्या १७ है ।)

(च) १. चक्रत्प्रोह्यं for (चक्रत्प्रोह्य) ६. तत्स्पष्ट for (तत्स्पष्टं)

(ङ) ३. पूर्ववत्क्षेषम् for (पूर्ववच्छेषम्)

(वि० श्लोक की दूसरी पंक्ति "क्षेप्य" शब्द से आरम्भ होती है ।)

१९. (ग) (वि० इसकी श्लोक संख्या १८ है)

(च) १. भुत्तथाकर्मादीनां for (भुत्तथाकर्मादीनां)

(ङ) १. भुत्तथाकर्मादीनां for (भुत्तथाकर्मादीनां)

मंडलशेषात्^३ स्वोच्चं^४ विशोध्य^५ शेषं^६ चतुर्गुणालब्धम् ।

केंद्रं यदा निजिनगुणा जीवा गतयेयगतयो यैः ॥ २० ॥

छेदचतुर्थे^१ बाहुय्येयागतगतैस्तथा कोटिः ।

प्राग्वदिनेन्दुभुजफलं तथाफलं भूसुतादिनाम् ॥ २१ ॥

फलचापकला गुणिते छेदे मंडलकलाहृत लब्धम् ।

मंडलशेषे पूर्ववद्वरणधनमस्माद् ग्रहः स्पष्टः ॥ २२ ॥

२०. (घ) १. गुणात् (ङ) for (गुणा) २. गतयेयैः (ग) गयेयैः for (गतयोयै)

(ग) ३. शेखात् for (शेषात्) ४. शेखाश्च for (शेषं च)

५. पदानि for (यदानि) (च) (ङ)

(वि० इसकी श्लोक संख्या १६ है ।)

(च) १. यै for (यैः)

(ङ) ४. सदृशं for (शेषं) ६. चतुर्गुणाल्लब्धम् for (चतुर्गुणालब्धम्)

२. गतयेयैः for (गतयोयैः)

२१. (घ) १. चतुर्थेर्बाहुय्ये (ग) चतुर्थेर्बाहु for (चतुर्थे बाहुय्ये)

२. यगतागतगवे (गे) यगतागतगतै for (यागतगतै)

३. सुतादीनाम् (ग) (ङ) for (सुतादिनाम्)

(ग) ४. 'भु' लुप्त है । (वि० इसकी श्लोकसंख्या २० है ।)

(च) १. चतुर्थेर्बाहुय्ये for (चतुर्थे बाहुय्ये) २. यगतागतगतैस्तथा (यागतगतैस्तथा)

३. सुतादीनां for (सुतादिनाम्)

(ङ) १. चतुर्थेर्बाहो for (चतुर्थेर्बाहु) २. यैयगता for (यैया)

५. मन्दफलं for (तथाफलं)

२२. (ग) १. कलाहृते ल्लब्धम् (ग) for (कलाहृत लब्धम्)

२. पूर्ववद्वरण (ग) (ङ) for (पूर्ववद्वरण)

(वि०—यहाँ संख्याक्रम २२ के स्थान में २३ लिखा हुआ है)

(ग) यहाँ श्लोक संख्या २१ है । २२ वाँ श्लोक इसके स्थान पर निम्नांकित है—
भुजकोटचं शो न गुणाभाद्धाशातश्चतुर्थं भागोनैः ।

पंच द्विंदुखचंद्रैर्विभाजिता व्यासदलगुणिताः ॥ २२ ॥

(च) १. हृतेल्लब्धं for (हृतलब्धम्) २. पूर्ववद्वरण for (पूर्ववद्वरणधन)

३. (वि० क्रमसंख्या २३ अंकित है ।)

(ङ) १. कलाहृते for (कलाहृत)

तज्ये^३ परमफलज्या संगुणितात् फ फले विनाद्याभिः ।
इष्टोच्चनीचवृत्तव्यासार्द्धं परमफलजीवा ॥ २३ ॥

२३. (घ) वि० अतिरिक्त श्लोक —

तज्ये परमफलज्या संगुणितात्फले विभुजकोट्यंशो न गुणा भाद्वीशास्तच्चतुर्थे
भागो नेः । पञ्चद्वीदुखचन्द्रं विभाजिता व्यासदलगुणिताः ॥ २३ ॥

(वि० यह श्लोक यहाँ २३ संख्याक्रम पर पाया गया)

२३. (घ) (वि० इसकी क्रम संख्या २४ है ।)

१. तत्फले (ग) संगुणितास्तत्फले for (संगुणितात्फले)

२. ज्याभिः (ग) (ङ) for (द्याभिः)

(ग) वि० अतिरिक्त श्लोक —

तत्तज्ये परमफलज्या संगुणितास्तत्फले विना ज्याभिः ।
इष्टोच्चनीचवृत्तः व्यासार्द्धं परमफलजीवा ॥ २३ ॥

३. तत् तज्ये for (तज्ये)

(वि० इसकी क्रम संख्या २३ है ।)

(च) यहाँ पर यह पंक्तियाँ लुप्त हैं—इनके स्थान में निम्नांकित शब्द किसी
अन्यलेख में-निम्नोपांत में अंकित हैं ।

“भुजकोट्यंशो गुणा भाद्वीशास्तच्चतुर्थं भातैः ।
पञ्चद्वीदुखचन्द्रं विभाजिता व्यासदलगुणिता ॥”

३. तद्ये for (तज्ये) १. संगुणितात्फले for (संगुणितात् फ फले)

(वि० क्रमसंख्या २४ अंकित है ।)

(ङ) २३ वां श्लोक निम्नांकित है—

भुजकोट्यंशोनगुणा भाद्वीशास्तच्चतुर्थभागोनैः ।
पञ्चद्वीदुखचन्द्रं विभाजिता व्यासदलगुणिता ॥ २३ ॥”

‘तज्ये.....जीवा’ की क्रमसंख्या २४ है ।

३. तज्ये for (तज्ये) १. तत्फले for (त् फले)

इष्टज्या संगुणिता^१ पंचकयमलेकं शून्यचन्द्रमसा^२ ।
 इष्टज्यापादयुतव्यासार्द्धविभाजितालब्धम् ॥ २४ ॥
 नवतिकृतेः प्रोह्यपदं नवतेः संशोध्य शेषकला^१ ।
 एवं धनुरिष्टाया^२ भवति ज्याया^३ विना ज्याभिः^४ ॥ २५ ॥
 इष्टोदयिकभुजांतरमितं^५ व स्फुट मध्यमांतरकलाभिः^६ ।
 वाश्विन्यौदयिकेषु^७ स्वचरप्राणैः^८ स्वफलमेवम् ॥ २६ ॥

२४. (घ) (वि० इसकी क्रमसंख्या २५ दी गई है ।)
 १. संगुणिता: (ग) (च) (ङ) for (संगुणिता)
 २. चन्द्रमसः (ग) शून्यचन्द्रमसः for (चन्द्रमसा)
 (च) २. चन्द्रमसः for (चन्द्रमसा) ३. इष्ट्या for (इष्टज्या)
 ४. (वि० क्रमसंख्या २५ अंकित है ।)
 (ङ) (वि० इस श्लोक की क्रमसंख्या २५ है)
 २. चन्द्रमसः for (चन्द्रमसा)
२५. (घ) १. कला: for (कला) (ग) शेषभागकला: or (शेषकला)
 २. धनुरिष्टयो for (धनुरिष्टाया) ३. ज्याया (ग) (च) (ङ) for (ज्याया)
 (वि० — इसकी संख्या २६ अंकित है)
 (ग) ४. विज्याभिः for (विनाज्याभिः)
 (च) १. शेषभागकला: for (शेषकला) २. रिष्ट्या for (रिष्टाया)
 ५. (वि० क्रमसंख्या २६ अंकित है)
 (ङ) १. शेषभागकला: for (शेषकला) ४. विनाज्याभि for (विनाज्याभिः)
 (वि० इसकी क्रमसंख्या २६ है)
२६. (घ) १. इष्टोदयिक (ङ) for (इष्टोदयिक)
 २. मिनवत् (ग) मिनवत् for (मितव)
 ३. नाश्विन्यौदयिकेषु (ग) नाश्विन्यौदयिकेषु for (वाश्विन्यौदयिकेषु)
 (ग) ४. भुजांतर for (भुजांतर) ५. स्वचरप्राणैः for (स्वचरप्राणैः)
 (च) ६. (वि० यहां क्रमसंख्या २७ अंकित है) (ङ)
 (ङ) २. वि० मिनवत् for (मितव) ७. मिनवत् for (मेवम्)
 ३. नाश्विन्यौदयिकेषु for (वाश्विन्यौदयिकेषु)

स्वोच्चं^१ विशोध्य^४ कृत्वा^५ प्राग्वत्फलमृणधनं^६ विपर्यस्वम्^७ ।
 कार्यामनष्टे^८स्पष्टे पुनः पुनर्निश्चलो मध्यः ॥ २७ ॥
 मानार्धात्^९ षष्टिगुणाद्भुक्तिं^{१०} हृतान्नाडिकादिलब्धेन ।
 राश्यंतान् प्राणादि पश्चादेतोर्कसंक्रांतेः^{११} ॥ २८ ॥
 संक्रांति पुण्यकालो यल्लब्धं नाडिकादि तद्विगुणम्^{१२} ।
 स्नानजपहोमादिकोत्र धर्मो विशिष्टफल^{१३} ॥ २९ ॥

२७. (घ) १. विविशोध्य (ग) स्वोच्चविशोध्य for (स्वोच्चं विशोध्य)

(वि० इसकी क्रमसंख्या २८ अंकित है)

(ग) २. विपर्यस्तम् (ङ) for (विपर्यस्वम्) ३. कार्यमनष्टे for (कार्यामनष्टे)

(च) ४. कृत्वा for (कृत्वा) ५. पुनः for (पुनः)

६. (वि० यहां क्रमसंख्या २८ अंकित है) (ङ)

(ङ) १. स्वोच्चाद् for (स्वोच्चं) ३. कार्यमनष्टस्पष्टे for (कार्यामनष्टस्पष्टे)

२८. (घ) १. प्राणादिः (ग) for (प्राणादि) २. पश्चादंतोर्क (ग) for (पश्चादेतोर्क)

(वि० इसकी क्रमसंख्या २९ अंकित है)

(ग) ३. हृता (ङ) for (हृता) ४. संक्रान्ते for (संक्रान्तेः)

(च) ५. षष्टी for (षष्टिः) १. प्राणादिः (ङ) for (प्राणादि)

२. पश्चादंतोर्कसंक्रांतेः for (पश्चादेतोर्कसंक्रांतेः)

६. (वि० यहां क्रमसंख्या २९ अंकित है) (ङ)

(ङ) २. पश्चादंतोर्क for (पश्चादेतोर्क) ७. मानार्धात् for (मानार्धात्)

२९. (च) १. पुण्यकालो (ग) (च) for (पुण्यकालो)

(वि० इसकी क्रमसंख्या ३० अंकित है)

(ग) २. होमदानादि (ङ) for (होमादि) ३. फलम् for (फल)

(च) ४. (वि० यहां क्रमसंख्या ३० अंकित है) (ङ) ।

(ङ) १. पुण्यकालो for (पुण्यकालो) ४. तद्विगुणम् for (तद्विगुणम्)

२. होमदानादिकोत्र for (होमादिकोत्र)

३. विशिष्टफलः for (विशिष्टफल)

एवं नक्षत्रांतातिथिकरणतो छशिप्रमाणाद्वात् ।
 षष्टिगुणात् रविशशिनोभुत्तचंतर लब्धघटिकाभिः ॥ ३० ॥
 संक्रांतिस्थो यावत्करोति मिश्रं फलं ग्रहस्तावत् ।
 यस्मात्तस्मादिष्टो राद्यंतौ परिहरति लोकः ॥ ३१ ॥
 चक्रार्द्धेऽर्कशशियुतौ भिन्नायनयोरपक्रमच्चे ।
 रविशशिनोः सममधुघृतयोगादिषु वध्यतिपातः ॥ ३२ ॥

३०. (घ) १. तिथि (ग) (च) for (तिथि) २. छसि (ग) शिशि for (छशि)
 (वि० इसकी क्रमसंख्या ३१ है)

(ग) ३. करणी for (करणतो) ४. (च) (ङ) द्रवि for (त्रवि)
 ५. भुत्तचतर for (भुत्तचंतर)

(च) ३. करणांताछसि for (करणतोछशि) ६. क्रमसंख्यालुप्त

(ङ) ७. नक्षत्रान्ता for (नक्षत्रान्ता) ३. करणान्ता for (करणतो)
 २. चछशि for (छशि) ५. भुत्तचन्तर for (भुत्तचंतर)
 (वि० इसकी क्रमसंख्या ३१ है) ।

३१. (घ) (वि० इसकी क्रमसंख्या ३२ है) १. विमिश्रं for (मिश्रं)

२. तस्माद्विष्टे (ग) तस्मादिष्टे for (तस्मादिष्टो)

३. परिहरति (च) (ङ) for (परिहरति)

(ग) ४. स्वाद्यंतौ for (राद्यंतौ) ५. (वि० क्रमसंख्या ३२ अंकित है) । (ङ)

(ङ) २. तस्माद्विष्टे for (तस्मादिष्टो)

३२. (घ) (वि० इसकी संख्या ३३ अंकित है) ।

१. चक्रार्द्धे (ग) चक्रार्धे for (चक्रार्द्धेऽर्क)

२. रपक्रमसमच्चे (ग) रूपक्रमसमत्वे for (रपक्रमच्चे)

३. योगद्विषवद्वातीपातः (ग) तद्वषवद्वातीपातः for (योगादिषुवध्यतिपातः)

(च) २. रपक्रमसमच्चे for (रपक्रमच्चे)

३. योगादिषुवद्वातीपातः for (योगादिषुवध्यतिपातः)

४. (वि० क्रमसंख्या ३३ अंकित है) (ङ)

(घ) २. रपक्रमसमत्वे for (रपक्रमच्चे) ३. योगाद्विषदो for (योगादिषु)

४. व्यतीपातः for (वध्यतिपातः)

च॒क्र॑ वै॒धुत॑मेकायतस्थयोः क्रा॒न्तिजीव॑योः सा॒म्ये ।
 धन॑रवि॒गणि॑योगादग्नि वदू॒नाधि॑क कल॒म्यः ॥ ३३ ॥
 भुक्त॑क्यलब्धदिवसैः रवी॑न्दुपा॒तायु॑तोनकाः स्वफ॒लैः ।
 अ॒र्कक्रा॑न्तिज्याधनु॒रिदो॑ वि॒क्षेप॑युक्तोनम् ॥ ३४ ॥
 त्रि॒नव॑ग्रहेंदु क्रा॒न्तिर्मे॒व तु॒लादौ॑ दि॒वाकर॑क्रा॒न्तः ।
 उ॒नाया॑वदभावस्तावद्भा॒वो न्य॒थाक॑न्दोः ॥ ३५ ॥

३३. (घ) १. मेकायस्थयोः (ग) मेकायनस्थयोः for (मेकायतस्थयोः)

२. इधन (ङ) (ग) (च) for (घन)

३. मणि (ग) (च) (ङ) for (गणि)

४. कलाम्यः (ग) (च) (ङ) for (कलम्यः)

(वि० इसकी क्रमसंख्या ३४ अंकित है) (ङ)

(ग) ५. जीवायाः for (जीवयोः) (प्रथम पंक्ति समाप्त)

६. दूसरी पंक्ति का अंतिम पद ।

७. वरूनाधिक for (वदूनाधिक)

(च) ८. क्रमसंख्या ३४ अंकित है (ङ) ।

(ङ) १. मेकायनस्थयोः for (मेकायतस्थयोः)

३४. (घ) १. भुक्तक्य (ग) (च) (ङ) for (भुक्तैक्य)

२. विक्षेप (ग) (च) (ङ) for (विक्षेप)

(वि०—इसकी क्रम संख्या ३५ अंकित है)

(च) ३. अर्क for (अर्क)

४. (वि०—यहां क्रमसंख्या ३५ अंकित है) (ङ)

(ङ) ५. दिवसै for (दिवसैः)

३५. (घ) १. त्रिनवग्रहेंदु (ग) (च) (ङ) for (त्रिनवग्रहेंदु)

२. मेष (ग) (च) (ङ) for (मेव)

४. ऊना (ग) (च) (ङ) for (उना) ५. अन्यथा (ङ) for (न्यथा)

(वि०—इसकी क्रमसंख्या ३६ अंकित है ।)

(च) ६. ऊँदोः for (केंदोः)

७. (वि०—यहां क्रमसंख्या ३६ अंकित है) (ङ)

(ङ) ३. दिवाकरक्रान्तेः for (दिवाकरक्रान्तः)

व्यतिपातयोपक्रमयोद्विसाम्ये वैधृतं दिगन्यत्वे ।
 अधिको दूनः कल्पो दिग्मेदेपक्रमः शशिनः ॥ ३६ ॥
 मेषतुलादाविन्दोरपक्रमेख्यपक्रमादुने ।
 एष्यत्यधिके तीतो विपरीतः कर्कमकरादौ ॥ ३७ ॥
 क्रान्त्योर्युतिरन्यदिशोरेकदिशोरन्तरं व्यतिपाते ।
 एकादशो युतिरन्तरमन्यदिशो वैधृते प्रथमः ॥ ३८ ॥

३६. (घ) (वि०—इसकी क्रमसंख्या ३७ अंकित है)
 १. व्यतिपातोपक्रमयो (ग) व्यतिपातोपक्रमयो for (व्यतिपातयोपक्रमयो)
 २. दिक्साम्ये (ग) दिक्साम्ये (च) for (द्विसाम्ये)
 ३. दिग्मेदे (ग) (च) for (दिग्मेदे)
 (ग) ४. अधिकाप्यूनः for (अधिकोदूनः)
 (च) १. व्यतिपातोपक्रमयो for (व्यतिपातयोपक्रमयो)
 ५. वैधृतं for (वैधृतं) ६. (क्रमसंख्या ३७ अंकित है) (ङ)
 (ङ) १. व्यतिपातोपक्रमयो for (व्यतिपातयोपक्रमयो)
 २. दिक्साम्ये for (द्विसाम्ये) ५. वैधृतो for (वैधृतं)
 ४. न्यूनः for (दूनः) ७. कल्पो for (कल्पो)
 ३. उपक्रमः for (पक्रमः)
३७. (घ) (वि०—इसकी क्रमसंख्या ३८ है)
 १. दूने (ग) दूने for (दुने) २. स्तीतो for (तीतो)
 ३. कर्क्वि (ग) कर्क्कि for (कर्कं)
 ४. मेषतुला for (मेषतुला)
 (च) १. दूने for (दुने) ३. कर्क्किमकरादौ for (कर्कमकरादौ)
 ५. (वि०—यहां क्रमसंख्या ३८ अंकित है) (ङ)
 (ङ) १. दूने for (दुने) २. त्यधिकोऽस्तीतो for (त्यधिकेतीतो)
 ३. कर्कं for (कर्कं)
३८. (घ) (वि०—इसकी क्रमसंख्या ३९ अंकित है)
 १. एकादशो (ग) एकादशोर्युति for (एकादशोयुति)
 (ग) २. व्यतिपाते (ङ) for (व्यतिपाते)
 (घ) १. एकादशोर्युति (ङ) for (एकादशोयुति)
 ३. (वि०—यहां क्रमसंख्या ३९ अंकित है) (ङ)
 (ङ) ४. वैधृते for (वैधृते)

एवं द्वितीयराशिपुतिहीने रिष्टनाडिकास्वफलः ।
 एष्यदतीत वा यदिराशिद्वयमपि तदन्तरकम् ॥ ३६ ॥
 छेदोन्यथा तदैवचं घातस्येष्टघटिका प्रथमराशयोः ।
 फलघटिकाभिर्मध्यं द्वयोरपि प्रथमराशिवशात् ॥ ४० ॥
 तात्कालिकं प्रहैरसकृदिष्टघटिकाफलोनयुक्तं स्तैः ।
 प्राग्वत्प्रथमे छेदः प्रमाणयोगाद्धलिप्तानाम् ॥ ४१ ॥
 इष्टघटिकागुणानामसकृत फलनाडिकाभिराद्यन्तैः ।
 व्यतिपापवैधृतानयनमन्यन्तं त्रेषु न ब्राह्म्यात् ॥ ४२ ॥

३६. (घ) (वि०—इसकी क्रमसंख्या ४० अंकित है)
 १. एष्यदतीतं for (एष्यदतीतं)
 (च) २. नाडिकाः for (नाडिका) १. ऐष्यदतीतं for (एष्यदतीतं)
 ३. (वि०—यहां क्रमसंख्या ४० अंकित है) (ङ)
 (ङ) ४. युतहीने for (युतिहीने)
४०. (घ) (वि०—इसका संख्याक्रम ४१ है)
 १. प्रमराशिवशात् for (प्रथमराशिवशात्)
 (ग) २. घतस्येष्ट for (घातस्येष्ट) ३. द्वरपि for (द्वयोरपि)
 (च) ४. (वि०—यहां क्रमसंख्या ४१ अंकित है) (ङ)
४१. (घ) (वि०—इसकी क्रमसंख्या ४२ है)
 १. फलोनक्तं स्तैः for (फलोनयुक्तं स्तैः)
 २. प्रथमछेदः (ग) प्रमछेदः for (प्रथमछेदः)
 (च) ३. रसकृदिष्ट for (रसकृदिष्ट) ४. (वि०—यहां क्रमसंख्या ४२ अंकित है) (ङ)
 (ङ) २. प्रथमरछेदः for (प्रथमछेदः)
४२. (घ) (वि०—इसकी क्रमसंख्या ४३ है)
 १. असकृतफल (ग) for (असकृतफल) २. राद्यन्तो (ग) for (राद्यन्तैः)
 ३. व्यतिपात (ग) व्यतीपात (ग) व्यतीपात for (व्यतिपाप)
 ४. ब्राह्मात् (ग) ब्रह्मात् for (ब्राह्म्यात्)
 (ग) ५. गुणानाम् for (गुणानाम्)
 (च) १. मसकृतफल for (मसकृतफल) ४. ब्राह्मात् for (ब्राह्म्यात्)
 ६. (वि०—क्रमसंख्या ४३ अंकित है) । (ङ)
 (ङ) १. असकृत् for (असकृत) २. राद्यन्तौ for (राद्यन्तैः)
 ३. व्यतिपात for (व्यतिपाप) ४. ब्राह्मात् for (ब्राह्म्यात्)

रविबिम्बमेकमार्गाच्छिशिबिम्बापक्रमे भवति यावत् ।
 तावत्फलं तदुक्तं तद्भावो तत्फलाभावः ॥ ४३ ॥
 ग्रहकक्षायनतुल्याः कक्षास्तन्मंदशीघ्रपातानाम् ।
 यस्मात्तस्मान्न पृथक्कक्षाः कल्प्याश्चलोच्चाद्याः ॥ ४४ ॥
 पौलिशरोमकवाशिष्टं सौरपैतामहेषु यत्प्रोक्तम् ।
 तन्नक्षानयनं नार्यभटोक्तं तदुक्तिरतः ॥ ४५ ॥

४३. (घ) (वि०—इसकी क्रमसंख्या ४४ है)

१. मार्गा (ग) मार्गात शशि for (मार्गाच्छिशि)

२. तदभावे (ग) तद्भावे for (तद्भावो)

(ग) ३. बिम्बापक्रमो for (बिम्बापक्रमे) ४. तावत्फलं for (तावत्फलं)

५. तत्फलोभावः for (तत्फलाभावः)

(च) २. तदभावे for (तद्भावो) ६. (वि०—क्रमसंख्या ४४ अंकित है) (ङ)

(ङ) १. मार्गाच्छिशि for (मार्गाच्छिशि) २. तदभावे for (तद्भावो)

४४. (घ) (वि०—इसकी क्रमसंख्या ४५ है)

१. पृथक्कक्षाः (ग) पृथक् कक्षायन for (पृथक्कक्षाः)

२. कल्प्याश्चलोच्चाद्याः (ग) कल्प्याश्चलोच्चाद्यात् for (कल्प्याश्चलोच्चाद्याः)

(ग) ३. ग्रहकक्षायन तुल्या for (ग्रहकक्षायनतुल्याः) ४. तस्मात्तते for (तस्मान्न)

(च) १. पृथक्कक्षाः for (पृथक्कक्षाः) ५. (वि० क्रमसंख्या ४५ अंकित है) (ङ)

(ङ) ३. कक्षयैव for (कक्षायन) १. पृथक् कक्षा for (पृथक्कक्षाः)

७. तुल्या कक्षा for (तुल्याःकक्षा) २. कल्प्या for (कल्प्याश्)

७. स्तनमंद शीघ्र for (तन्मन्द) ८. चलोच्चाद्या for (चलोच्चाद्याः)

४५. (घ) (वि०—इसकी क्रमसंख्या ४६ है)

१. तन्नक्षत्रानयनम् (ग) for (तन्नक्षानयनं)

(ग) २. पौलिश for (पौलिश) ३. सौर्य for (सौर)

(च) १. तन्नक्षत्रानयनं for (तन्नक्षानयनं) ४. (यहां क्रमसंख्या-‘४६’ अंकित है।)

(ङ) ५. वाशिष्ट for (वाशिष्ट)

अध्वर्द्धाद्विं क्षेत्रान्यूडुनि षट् षट् भवन्ति पञ्चदशाः ।
 ऋक्षाणि समक्षेत्राण्यभिजिद्भोगो भवत्येकः ॥ ४६ ॥
 कैशादित्यविशाखा प्रोष्ट पदार्थम्ल वैश्वदेवानि ।
 षट् षट् ज्येष्ठाभरणी स्वात्यर्द्धा राहूणाश्लेषा ॥ ४७ ॥
 पंचदशात्रानुक्ता न्येको भिजदुत्तरक्षभोगोन्यः ।
 तन्मानं नाक्षत्रं दुरधिगमं मंदबुद्धिनाम् ॥ ४८ ॥

४६. (घ) (वि० इसकी क्रमसंख्या ४७ है)

१. अध्वर्द्धाद्विं (ग) (च) for (अध्वर्द्धाद्विं)
२. क्षेत्राण्यूडुनि (ग) for (क्षेत्रान्यूडुनि) ३. षट् (ग) षट् for (षट्)
- (ग) ४. 'षट्' पद लुप्त है ५. दशः for (दशाः)
- (च) २. क्षेत्राण्यूडुनि for (क्षेत्रान्यूडुनि) ३. षट् for (षट्)
६. (यहाँ क्रमसंख्या ४७ अंकित है ।) (ङ) ।
- (ङ) अध्वर्धानि भवन्ति षट् नक्षत्राण्यूडुनि षडर्धानि ।
 पञ्चदश समक्षेत्राण्यभिजिद्भोगो भवत्येकः ॥ ४७ ॥
 for

"अध्वर्द्धाद्विं क्षेत्रान्यूडुनि षट् षट् भवन्ति पञ्चदशाः ।

ऋक्षाणि समक्षेत्राण्यभिजिद्भोगो भवत्येकः ॥ ४६ ॥

४७. (घ) (वि० इसकी क्रमसंख्या ४८ है)

१. वैश्वदेवानि (ग) (च) (ङ) for (वैश्वदेवानि)
२. स्वात्यर्द्धा (ग) for (स्वात्यर्द्धा) ३. श्लेषाः (ङ) for (श्लेषा)
- (ग) ४. मदार्थम्ल for (पदार्थम्ल)
- (च) ५. विशाखा for (विशाखा) ६. प्रोष्ट for (प्रोष्ट)
२. स्वात्यर्द्धा for (स्वात्यर्द्धा) ३. श्लेषाः (ङ) for (श्लेषा)
७. (वि० — यहाँ क्रम संख्या अंकित नहीं है)
५. पदार्थम्ल for (पदार्थम्ल) २. स्वात्यर्द्धा for (स्वात्यर्द्धा)

४८. (घ) (वि० — इसकी क्रमसंख्या ४९ है)

१. भिजिदुत्त (ङ) for (भिजिदुत्त)
२. भोगोन्यः (ग) भोगान्यः for (भोगोन्यः) ३. तत्मानं for (तन्मानं)
४. मंदबुद्धिनाम् (ग) (च) मंदबुद्धिनां for (मंदबुद्धिनाम्)
- (ग) ५. ऋक्ष (ङ) for (रक्ष) (च) ३. तत्मानं for (तन्मानं)
६. (वि० — यहाँ क्रमसंख्या ४९ अंकित है) (ङ)
- (ङ) ३. यस्माद् तन्नाक्षत्रं for (तन्मानं नाक्षत्रं) ४. मन्दबुद्धिनाम् for (मंदबुद्धिनाम्)

अध्यर्द्धा^२ समक्षेत्राणां मध्यगते^३ लिप्तिकाः शशिनः ।
 अध्यर्द्धा^४र्द्धैकगुणा भभोगलिप्तास्तदैकयोना ॥ ४६ ॥
 मंडललिप्ताः शेषो भोगोभिजित् शशोक भगणा वा ।
 त्रिघनगुणाः संशोष्याः कल्पदिनेभ्यो यदवशेषम् ॥ ५० ॥
 तद्भगणैर्दिनभोगो^१ भिजितो भभोगलिप्तोनाः ।
 भानि ग्रहभुक्तकला गतगम्या गतिहृता दिवसाः ॥ ५१ ॥
 भफलं प्रोक्तमभिजितो मंगलपात्रासु संहिताकारैः ।
 यैस्तद्भोगोनोक्तास्ते गणकाः संहिताबाह्याः ॥ ५२ ॥

४६. (घ) (वि०—इसकी श्लोक संख्या ५० अंकित है)
 १. तदैकयोनाः (च) (ङ) for (तदैकयोना)
 (ग) २. अध्यर्द्धा^२ for (अध्यर्द्धा) ३. मध्यगति (ङ) for (मध्यगते)
 (च) ४. अध्यर्द्धा^४र्द्धैक for (अध्यर्द्धा^४र्द्धैक)
 ५. (वि०—यहां क्रमसंख्या ५० अंकित है) (ङ)
 (ङ) २. अध्यर्द्धा^४र्द्धैक for (अध्यर्द्धा) ४. अध्यर्द्धा^४र्द्धैक for (अध्यर्द्धा^४र्द्धैक)
५०. (घ) (वि०—इसकी क्रमसंख्या ५१ है)
 १. भोगोभिजित् (ग) भोगोभिजितः for (भोगोभिजित्)
 (ग) २. शशोक for (शशोक) ३. भगणैर्वा for (भगणावा)
 (च) ४. (वि०—यहां क्रमसंख्या ५१ है) (ङ)
 (ङ) १. अभिजितोभोगः for (भोगोभिजित्)
५१. (घ) (वि०—इसकी क्रमसंख्या ५२ है)
 १. भुक्तिभोगाभिजितो (ग) दिनभुक्तिभोगो for (दिनभोगो)
 २. हृता (ग) (च) for (हृता)
 (ग) ३. लिप्तोनाम् for (लिप्तोनाः) ४. भुक्ति for (भुक्त)
 ५. दिवसा for (दिवसाः)
 (च) ६. (वि०—यहां क्रमसंख्या ५२ है) (ङ)
 (ङ) १. अभिजितो for (भिजितो) ७ + भोगो +
५२. (घ) (वि० इसकी क्रमसंख्या ५३ है) १. नोक्तस्ते (ग) (ङ) for (नोक्तास्ते)
 (ग) २. संहिता for (संहिता)
 (च) ३. यात्रासु for (पात्रासु) ४. (वि०—यहां क्रमसंख्या ५३ अंकित है) (ङ)
 (ङ) ३. यात्रासु for (पात्रासु)

अर्ध्याद्विक्षेत्राणि संहिता स्वभिहितानि गर्गाद्यैः ।
यस्मादुद्भूतस्मान्नार्यभटोक्तं तदानयनम् ॥ ५३ ॥
आर्याणां पञ्चांशच्चतुर्भिरधिका चतुर्दशोऽध्यायः ।
चतुर्दशोऽध्यायः समाप्तः

५३. (घ) (वि०—इसकी क्रमसंख्या ५४ है)

१. अर्ध्यादी (ग) अर्ध्यादी for (अर्ध्याद्वि) २. क्षेत्राणि for (क्षेत्राणि)

(ग) ३. यस्मादुद्भूति (च) for (यस्मादुद्भूति)

(च) १. अर्ध्याद्विक्षेत्राणि for (अर्ध्याद्विक्षेत्राणि)

४. (वि०—यहां क्रमसंख्या ५४ अंकित है) ।

(ङ) १. अर्ध्यादी for (अर्ध्याद्वि) ३. यस्मादुद्भूति for (यस्मादुद्भूति)

५४. (घ) १. चतुर्भि (ग) चतुर्भि for (चतुर्भि) २. चतुर्दशो (ग) for (चतुर्दशो)

(ग) 'चतुर्दशो' से 'समाप्तः' तक अंकित नहीं है । इसकी दूसरी पंक्ति निम्नांकित है
'स्फुटगतिरुत्तरमन्या दिशा ब्यूह्यत्प्रस्तात् ॥५४॥

(च) १. पञ्चांशच्चतुर्भिरधिका for (पञ्चांशच्चतुर्भिरधिका)

२. चतुर्दशोऽध्यायः for (चतुर्दशोऽध्यायः)

३. 'छ' for (चतुर्दशोऽध्यायः समाप्तः)

(ङ) १. चतुर्भि for (चतुर्भि)

४. + स्फुटगत्युत्तरमन्यान् दिशाऽनयया ऽभ्युपगमेत् प्रश्नान् ॥५५॥

३. इति स्फुटगत्युत्तराध्यायश्चतुर्दशः for (चतुर्दशोऽध्यायः समाप्तः)

अथ त्रिप्रश्नोत्तराध्यायः

पञ्चदशः

स्फुटगत्युत्तरमन्या दिशानयाप्पूहयेत्प्रश्नम् ।

योऽह्णपूर्वापरयोस्तुल्यछायांगुलाग्रयो बिन्दु ।

विक्षयाक्रान्त्याक्षांशं विना दिशो वेत्ति गणकः सः ॥ १ ॥

त्रिछायाग्रज्ञो यः क्रान्त्यक्षार्कं विना दिशो भ्रमणम् ।

छायाग्रस्य दिनाद्धं छायां वा वेत्ति गणकः सः ॥ २ ॥

यः छायाग्रं दृष्ट्वा क्रान्त्यक्षज्ञो दिशो विजानाति ।

शंकुछायाभ्रमरो दिक्ज्ञो वा वेत्ति गणकः सः ॥ ३ ॥

१. (घ) १. प्रश्नात् (च) for (प्रश्नम्) २. (वि०—यहाँ पर समाप्तिसूचक चिह्न है)
 ३. योऽह्ण (ग) येह्णः for (योह्ण) ४. बिन्दु (ग) बिन्दुः for (बिन्दु)
 ५. वीक्ष्य (ग) for (विक्ष्य) ६. विना (ग) for (विना)
- (ग) ७. स्फुटगतिरुत्तर for (स्फुटगत्युत्तर)
 ८. व्यूयत्प्रस्तात् ॥ ५४ ॥ for (पूहयेत् प्रश्नम्)
- (च) ३. योऽह्ण for (योह्ण) ५. विक्ष्य for (विक्ष्या)
 ४. बिन्दु for (बिन्दु) ६. विना for (विना)
- (ङ) ३. योऽह्ण for (योह्ण) ४. बिन्दु for (बिन्दु)
 ५. वीक्ष्य for (विक्ष्या) ७. क्रान्त्यक्षांशं for (क्रान्त्याक्षांशं)
 ६. विना for (विना)
२. (घ) १. त्रिछाया for (त्रिछाया) २. दि अद्धं छायां (ग) दिनाद्धं for (दिनाद्धं)
 (ग) ३. क्रान्ति क्षार्कं विना for (क्रान्त्यक्षार्कं विना)
 (च) ३. क्रान्त्यक्षार्कं for (क्रान्त्यक्षार्कं)
 (ङ) १. त्रिच्छाया for (त्रिछाया) ३. क्रान्त्यक्षार्कं विना for (क्रान्त्यक्षार्कं विना)
 २. दिनार्धच्छायां for (दिनाद्धं छायां)
३. (ग) १. दिशो for (दिशो) २. “सः” यहाँ यह पद लुप्त है
 ३. यश्छायाग्रं for (यः छायाग्रं)
 (वि० इसकी श्लोक संख्या ४ है । तीन की संख्या का श्लोक लुप्त है ।)
- (च) ४. क्रान्त्यक्षज्ञो for (क्रान्त्यक्षज्ञो)
 (ङ) ३. यश्छायाग्रं for (यः छायाग्रं) १. दिक्ज्ञो for (दिक्ज्ञो)
 ५. शंकुच्छाया for (शङ्कुछाया)

दृष्ट्वा विषुवच्छायां लम्बश्नेज्ये करोति यो बहुधा ।
 मध्यच्छायार्कज्ञो श्नांशान्यो वेत्ति गरणकः सः ॥ ४ ॥
 यश्चरखंडकलंकोदयाद्विजानाति लग्नमुदयैः स्वैः ।
 लग्ना घटिका छायांगत शेषनताच्च गरणकः सः ॥ ५ ॥
 गतशेषनता घटिका छायातो भिष्टदिनदलछायां ।
 बहुधार्कक्रान्त्यदनान् दृष्ट्वा यो वेत्ति गरणकः सः ॥ ६ ॥

४. (घ) १. लंबक्षोज्य (ग) for (लंबथेज्ये)
 २. श्नांशान् (ग) श्नांशान् for (श्नांशान्)
- (ग) (वि० इसकी श्लोक संख्या ५ है)
- (च) १. लंबक्षेज्ये for (लंबश्नेज्ये) ३. मध्यच्छायाऽर्कज्ञो for (मध्यच्छायार्कज्ञो)
 २. श्नांशान् for (श्नांशान्)
- (ङ) ४. विषुवच्छायां for (विषुवच्छायां) १. लंबाक्षज्ये for (लंबश्नेज्ये)
 ३. मध्यच्छाया for (मध्यच्छाया) २. श्नांशान् for (श्नांशान्)
५. (घ) १. खंड (ग) for (खंडकलं) २. लग्नादघटिका (ग) for (लग्नाघटिका)
- (ग) (वि० इसकी श्लोक संख्या ६ है)
 ३. श्छाया for (छायांगत) ४. नताश्च (च) for (नताच्च)
- (च) २. लग्नादघटिका for (लग्नाघटिका) ४. नताच्च for (नताच्च)
- (ङ) १. खण्डक for (खंडक) ५. लङ्कोदयान् for (लङ्कोदयाद्)
 २. लग्नाद् for (लग्ना) ३. घटिकाश्छायां for (घटिकाछायां)
६. (घ) १. ऽभीष्ट (ग) भीष्ट for (भिष्ट) २. क्रान्त्यक्षान् (ग) for (क्रान्त्यदनान्)
- (ग) ३. श्छायातो (ङ) for (छायातो) ४. छायाः for (छायां)
 (वि० इसकी श्लोक संख्या ७ है)
- (च) १. ऽभीष्ट (ङ) for (भिष्ट)
 २. बहुधार्कक्रान्त्यक्षान् for (बहुधार्कक्रान्त्यदनान्)
- (ङ) ४. दलच्छायाम् for (दलछायां)
 २. बहुधा क्रान्त्यर्कक्षान् for (बहुधार्क क्रान्त्यदनान्)

क्रांतिज्ञः सममंडल शंकुकर्णं वयोश्नलंबज्ञः ।

जानाति कोणशंकुछाया घटिकाः स तंत्रज्ञः ॥ ७ ॥

शंकुतलप्राच्यपरांतरद्वयं विक्षयो विजानाति ।

विषुवच्छायामेकं द्रष्टृवादित्यं च गणकः सः ॥ ८ ॥

पातलशंकुमुदयेन्दुस्ते वा दृग्ज्यां खे विजानाति ।

द्रक् पाताल द्रक्शंकोः पृथक् तले वा स तंत्रज्ञः ॥ ९ ॥

७. (घ) १. क्रांतिज्ञः for (क्रांतिज्ञः) २. शंकुं (च) (ङ) for (शंकु)
 ३. कर्णः (च) for (कर्ण)
 ४. वयोश्नलंबज्ञः (ग) च योश्नलंबज्ञः for (वयोश्नलंबज्ञः)
 ५. जानाति जानाति for (जानाति) ६. शंकुं for (शंकु)
 (ग) (वि०— इसकी श्लोक संख्या ८ है)
 (च) ४ वयोश्नलंबज्ञः for (वयोश्नलंबज्ञः)
 (ङ) ३. कर्णं च for (कर्णं व) ४. योश्नलंबज्ञः for (योश्नलंबज्ञः)
 ६. शंकुच्छाया for (शंकुच्छाया)
८. (घ) वीक्ष (ग) वीक्ष्य for (विक्षयो)
 २. दृष्ट्वादित्यं (ग) (च) for (द्रष्ट्वादित्यं)
 (ग) (वि०— इसकी श्लोकसंख्या ९ है)
 (च) १. वीक्ष for (विक्ष) ३. व for (च)
 (ङ) १. वीक्ष्य for (विक्ष) ४. विषुवच्छाया for (विषुवच्छाया)
 २. दृष्ट्वाऽऽदित्यं for (द्रष्ट्वादित्यं)
९. (घ) १. मुदयेऽस्ते (ग) मुदयेऽस्ते for (मुदयेऽस्ते)
 २. दृग्पातालगशंकुकोः (ग) दृग्पातालगशंकुकोः for (द्रक्पाताल द्रक्शंकोः)
 (ग) ३. विजानाति for (विजानाति)
 ४. तंत्रज्ञः for (तंत्रज्ञः) ५. पाताल for (पातल)
 (वि०— इसकी भी श्लोकसंख्या ९ है)
 (च) ५. पाताल for (पातल) २. दृग्पाताल for (द्रक्पाताल)
 ६. द्रक्शंकोः for (द्रक्शंकोः)
 (ङ) ५. पाताल for (पातल) २. दृक्पाताल for (द्रक्पाताल)
 १. मुदयेऽस्ते for (मुदयेऽस्ते) ३. खे विजानाति for (खे विजानाति)
 ६. गशङ्कोः for (द्रक्शंकोः)

दिनगतशेषप्राणरिष्टार्को^२ दिनदलान्तैरथवा ।

भवति सममंडले^५ यैर्यस्तान् कथयति स तंत्रज्ञः ॥ १० ॥

सममंडलगः प्राणदिनगत शेषं^३ नतै^१ दिनाद्धा^४द्वा ।

यै^५ भवति ज्ञात्वा तान्योऽर्कं^६ कथयति स तंत्रज्ञः ॥ ११ ॥

यः सममंडलशंकु^७कर्णं^८ व वीक्ष^९ सूर्यमानयति^२ ।

रविसममंडलशंकुजो^५ क्षं^६ कथयति स तंत्रज्ञः ॥ १२ ॥

रविलग्नान्तर घटिका^१ विनोदयैर्लग्नमिष्टघटिकाभिः ।

वेत्ति चराद्धादिकं^३ योर्कज्ञो^४ वा स तंत्रज्ञः ॥ १३ ॥

अक्षचराद्धाज्ञार्कं^३ छायातो यश्चराद्धमिष्टायाः ।

इष्टचराद्धादिव^५ छायां^६ कथयति स तंत्रज्ञः ॥ १४ ॥

१०. (घ) १. रिष्टाऽर्को (ग) रिष्टार्को for (रिष्टार्को)

(ग) २. दिनगते for (दिनगत) ४. दिनदलान्तैरथवा for (दिनदलान्तैरथवा)

५. समंडले for (सममंडले)

६. तंत्रज्ञः for (तंत्रज्ञः)

(च) १. ऽर्को for (को)

११. (घ) १. नतै (ग) (च) (ङ) for (नतै)

२. दिनाद्धाद्वा (च) for (दिनाद्धाद्वा)

(ग) ३. सममंडलगं for (सममंडलगः)

४. यैर्भवति (च) for (यैर्भवति)

५. न्योर्कं for (न्योऽर्कं)

(च) ५. तान्योऽर्कं for (तान्योऽर्कं)

(ङ) १. दिनाद्धाद्वा for (दिनाद्धाद्वा)

६. योऽर्कं for (योऽर्कं)

१२. (घ) १. शंकु (ग) (ङ) for (शंकु)

२. वा (च) (ङ) for (व)

३. वीक्ष्य (च) (ङ) for (वीक्ष)

४. कथति (च) for कथयति

(ग) ५. समंडल for (सममंडल)

(ङ) ६. ऽक्षं for (क्षं)

१३. (ग) १. घटिको for (घटिका)

२. लग्न for (लग्न)

(च) ३. योऽर्कज्ञो for (योर्कज्ञो)

(ङ) ३. योऽर्कज्ञो for (योर्कज्ञो)

१४. (घ) १. यस्यराद्धं (ग) यश्चचरार्धं for (यश्चराद्धं)

२. कथति for (कथयति)

(ग) ३. चराद्धंज्ञो for (चराद्धाज्ञार्कं)

४. चराद्धादिव for (चराद्धादिव)

(च) ३. ज्ञार्कं for (ज्ञार्कं)

(ङ) ३. चराद्धंज्ञो for (चराद्धाज्ञार्कं) ४. चराद्धादिव for (चराद्धादिव)

मध्यच्छायातो^१ क्षविदानयति^२ रविवाक्^३ रजोश्नं^४ ।
 योग्राकंज्ञो^५ लंबाक्षज्ये^६ कथयति स तंत्रज्ञः ॥ १५ ॥
 उदयेस्तमये^७ चाग्रां^८ वेत्ति^९ दिनाद्धं^{१०} नतोन्नतज्ययः^{११} ।
 ताभिर्विषुवच्छाया^{१२} श्नज्यालंबान्^{१३} स तंत्रज्ञः ॥ १६ ॥
 दिनरात्र्यर्धे^{१४} यश्चरदलाद्^{१५} विना^{१६} स्वेकरोति^{१७} वाताभ्यां^{१८} ।
 अक्षावलंबकौ^{१९} वा नस्तमयाकर्त्ति^{२०} तंत्रज्ञः ॥ १७ ॥

१५. (घ) १. छायातोक्षविदानयति (ग) तोक्षविदानविद for (छायातोक्षविदानयति)
 २. रविवाकरजोक्षम् (ग) रविदिवाकरजोक्षम् for (रविदिवाकरजोक्षम्)
 ३. लोबाक्षज्ये for (लम्बाक्षज्ये)
- (च) २. रविवाकरजोक्षं for (रविवाकरजोश्नं) ३. योग्राकंज्ञो for (योग्राकंज्ञो)
 ४. लंबाक्षज्ये for (लंबाक्षज्ये)
- (ङ) ५. मध्यच्छायातो for (मध्यच्छायातो)
 १. क्ष for (क्ष) ३. योग्राकंज्ञो for (योग्राकंज्ञो)
 ६. रवि for (रवि) २. दिवाकरजोक्षम् for (वाकरजोश्नं)
 ४. लम्बाक्षांशान् for (लम्बाक्षज्ये)
१६. (घ) १. चाग्रां (ग) (ङ) for (चाग्रां) २. ज्ये (ग) ज्येयः for (ज्ययः)
 ३. क्षज्या (ग) क्षप्या for (श्रज्या)
- (ग) ४. विषुवा for (विषुवच्छाया) ५. लंबात् for (लंबान्)
- (च) ३. क्षज्या for (श्नज्या)
- (ङ) ६. उदयेस्तमये for (उदयेस्तमये) २. ज्ये यः for (ज्ययः)
 ४. विषुवच्छाया for (विषुवच्छाया) ३. क्षज्या for (श्रज्या)
१७. (ग) १. नस्तमयाकौ for (नस्तमयाकर्त्तौ) २. नस्तमयाकौ for (नस्तमयाकर्त्तौ)
 ३. न स for (त्स)
- (च) ४. दिनरात्र्यर्धे for (दिनरात्र्यर्धे) १. नस्तमयाकर्त्ति for (नस्तमयाकर्त्ति)
- (ङ) ४. 'लुप्त' for (दिनरात्र्यर्धे) ५. दलंविना for (दलादविना)
 ६. +दिनरात्र्यर्धे+ १. नस्तमयाकर्त्तौ for (नस्तमयाकर्त्तौ)

आय^१ निवक्तॄणां^३ प्रश्नानामुत्तरं^४ चतुःषष्टि^५ ।
 आयास्त्रिप्रश्नोक्ताशेषप्रश्नोत्तरोक्तिरतः ॥ १८ ॥
 विषुवच्छाया^५ गुणिता^१ स्वाहोरात्र्याद्ध^२ भाजिता^४ त्रिज्या^५ ।
 क्रान्तिद्वादशगुणिता^३ फलचापकला^३ श्रुभिः^३ सहितैः ॥ १९ ॥
 स्वचरप्राणैर्दिनगतशेषः^३ सममंडले^३ रविर्भवति ।
 फलचापाशून्यभिस्तिथिघटिकाभि^३ नताभिर्वा ॥ २० ॥
 उदयसममंडलान्तरं^३ घटिकाज्यालंबकाहतं^३ गुणयेत् ।
 अक्षज्यया^३ हृतां^४ ततः^४ तत्क्रान्त्या^४ व्यासार्द्धसंगुणया ॥ २१ ॥

१८. (घ) १. आयानिवक्तॄणां (ग) (ङ) for (आयनिवक्तॄणां)
 २. आयास्त्रि (ग) (च) for (आयास्त्रि)
 (ग) ३. प्रश्नानां for (प्रश्नानां) ४. प्रश्नोक्ताः for (प्रश्नोक्ता)
 (च) १. आयानिवक्तॄणां for (आयनिवक्तॄणां)
 (ङ) ५. षष्ट्या for (षष्टिः) २. आयाणां for (आयास्त्रि)
 ४. प्रश्नोक्त्या for (प्रश्नोक्ता)
१९. (घ) १. गुणित (ग) गुणित (ङ) for (गुणिता)
 २. रात्रार्ध (ग) (ङ) for (रात्र्याद्ध)
 (ग) ४. त्रिज्याः for (त्रिज्या)
 (च) १. गुणित for (गुणिता) २. रात्र्याद्ध for (रात्र्याद्ध)
 ३. कलाश्रुभिः for (कलाश्रुभिः)
 (ङ) ५. विषुवच्छाया for (विषुवच्छाया)
२०. (घ) १. चापाशून्याभि (ग) चापास्तनुभि for (चापाशून्याभि)
 २. नतानिर्वाः (ग) नताभिर्वा for (नताभि)
 (च) ३. दिन for (दिन) १. शून्याभि for (शून्याभिः)
 २. नतानिर्वाः for (नतानिर्वा)
 (ङ) १. चापाशून्याभि for (चापाशून्याभि) २. नताभि for (नताभि)
२१. (घ) १. ज्यां (ङ) for (ज्या) २. लंबकाहता (ङ) (ग) लंबकाहतां for (लंबकाहतं)
 ३. अक्षज्यया (ग) अक्षज्या for (अक्षज्यया)
 ४. हृतांतक्रान्त्या (ग) हृतांत्यक्रान्त्या for (हृतांत ततत्क्रान्त्या)
 (ग) ५. मंडलान्तरघटिकाज्यां for (मंडलान्तरं घटिकाज्या)
 (च) २. हृतां for (हृतं) ४. हृतांतक्रान्त्या for (हृतांततत्क्रान्त्या)
 (ङ) ४. हृताज्यक्रान्त्या for (हृतांत ततत्क्रान्त्या)

लब्धधनुरविरजाक्ष कर्कटकादौ विशोद्ध चक्राद्धात् ।
 तज्या तदुदय सममंडलांतरा क्षुज्ययाभक्ता ॥ २२ ॥
 प्रश्न सममण्डला सुक्रमज्यया संगुणा सकृत्सूर्यः ।
 प्रश्न घटिकाभिरेवं गतघटिकाभिर्भवत्यहः ॥ २३ ॥
 त्रिज्यादिनाद्धसममंडलांतरा सुज्यायाः कृतिविशेषः ।
 स्वविषयविषुवच्छाया वर्गेण गुणो द्विधा प्रथमाः ॥ २४ ॥
 व्यासाद्धवर्गभक्तौ लब्धं ध्वादशकवर्गं संयुक्तम् ।
 छेदो द्वितीयराशे लब्धं पदं क्रान्तिरर्कातः ॥ २५ ॥

२२. (घ) १. रजादौ (ग) (च) for (रजाक्ष) २. विशोध्य (ग) (च) for (विशोद्ध)
 (च) ३. कर्कट for (कर्कट) ४. सुज्यया for (क्षुज्यया)
 (ङ) ५. रिनो for (रवि) १. रजादौ for (रजाक्ष)
 ३. कर्क्याकौ यदि for (कर्कटकादौ) २. विशोध्य for (विशोद्ध)
 ६. तज्या for (तज्या)
२३. (घ) १. गत शेषोभिर्भवत्यहः (ग) गतशेषाभिर्भवत्यहः for (गतघटिकाभिर्भवत्यहः)
 (ग) २. प्रश्न for (प्रश्न) ३. प्रश्न for (प्रश्न)
 (च) ४. सकृत्सूर्यः for (सकृत्सूर्य) ४. गतशेषाभि (ङ) for (गतघटिकाभि)
 ५. भवत्यहः (ङ) for (भवत्यहः)
 (ङ) ४. सकृत् सूर्यः for (सकृत्सूर्यः)
२४. (घ) १. सुज्ययोः (ग) (ग) (ङ) for (सुज्यायाः)
 २. विषुवच्छाया (ग) (च) for (विषुवच्छाया)
 ३. प्रथमः (ग) (च) (ङ) for (प्रथमाः)
 (ग) ४. दिनासम for (दिनाद्धसम) ५. स्वविष for (स्वविषय)
 (च) २. विषुवच्छायावर्गेण for (विषुवच्छायावर्गेण)
२५. (घ) १. वर्ग for (वर्ग) (ग) वर्गभक्तौ for (वर्गभक्तौ)
 २. द्वादश (ग) for (द्वादश) ३. संयुक्ताम् for (संयुक्तम्)
 ४. लब्धपदं (ग) (च) (ङ) for (लब्धपदं)
 (च) ५. रर्कातः for (रर्कातः)
 (ङ) १. व्यासार्धं वर्गभक्तौ for (व्यासाद्धवर्गं भक्तौ)
 २. द्वादश for (द्वादशक) ४. रर्कोऽतः for (रर्कातः)

सममण्डल शंकुगुणाक्षज्या^३ जीन^१भागजीवया^२ भक्ता ।
 फलधनुरर्को जादौ कर्क्यादौ^२ प्रोह्य चक्रार्द्धात् ॥ २६ ॥
 द्वादशगुणिताक्षज्या विषुवच्छायो^३ गुणावलंबज्या ।
 सममंडल कर्कादौ क्रान्तिज्ये भास्करः प्राग्वत् ॥ २७ ॥
 परमापक्रमजीवा तत्कालिकसूर्यबाहुसंगुणिता ।
 सममंडलशंकुहृताक्षज्या तच्चापमक्षांशाः ॥ २८ ॥
 लंकोदयचरदलवद्विलग्नान्ध्यां पृथक् पृथक् प्राणाः ।
 कृत्वा तदंतरैवचं मृगकर्क्यादिषु पृथक् लिप्ताः ॥ २९ ॥

२६. (घ) १. दिन (ग) जिन for (जीन) २. भक्ताः (ग) for (भक्ता)

(ग) ३. क्षय्या for (क्षज्या)

(च) ३. जिनभाग for (जीनभाग) ४. धनुरर्को for (धनुरर्को)

(ङ) ३. क्षज्या for (क्षय्या) १. जिन for (जीन)

४. रर्कोज्जादौ for (रर्कोजादौ)

२७. (घ) १. कर्णकृते (ग) कर्णहृते (ङ) for (कर्कादौ)

(ग) २. क्षय्या for (क्षज्या)

३. विषुवच्छाया for (विषुवच्छायो) (च) for (विषुवच्छायो)

(च) १. कर्णहृते for (कर्कादौ)

(ङ) २. क्षज्या for (क्षय्या) ३. विषुवच्छाया for (विषुवच्छायो)

२८. (घ) १. तात्कालिक for (तत्कालिक)

(ग) २. हृता for (हृता)

३. क्षय्या for (क्षज्या)

(ङ) ३. क्षज्या for (क्षय्या)

२९. (घ) १. प्राणान् (ग) (च) for (प्राणाः)

२. मृगकर्क्यादिषु (ग) मृगकर्कादिषु for (मृगकर्क्यादिषु)

३. पृथग्लिप्ताः (ग) (च) (ङ) for (पृथक्लिप्ताः)

(ग) ४. लंकोदयचरदलवद्वि for (लंकोदयचरदलवद्वि)

(च) २. मृगकर्क्यादिषु for (मृगकर्क्यादिषु)

(ङ) १. प्राणान् for (प्राणाः)

मेषादिषु कर्कादिषु विशोध्य भाद्धा तुलादिषु सभाद्धा ।
 मकरादिषु संशोध्याश्चक्ररवि भुक्ता लिप्ता वा ॥ ३० ॥
 लग्नकालायद्यूना सचकालिप्ता विना स्वराश्रयदयैः ।
 एवं स्फुटाभवंत्यर्कं लग्नयोरंतरप्राणाः ॥ ३१ ॥
 अष्टयमाश्रुत्य गुणा दिगिषु कालीना रदाः सतिथिलिप्ताः ।
 स्वचराद्धांशैरूना विपरीता संयुता व्यस्तैः ॥ ३२ ॥

३०. (घ) १. कर्कादिषु (ग) कर्कादिषु (ङ) for (कर्कादिषु)
 २. भाद्धात् (ग) for (भाद्धा) ३. सभाद्धाः (ग) for (सभाद्धा)
 ४. चक्राद्वि (ग) (च) (ङ) for (चक्ररवि)
 ५. भुक्तलिप्ताः (ङ) (ग) भुक्तलिप्ताः for (भुक्तलिप्तावा)

- (च) १. कर्कादिषु for (कर्कादिषु) ६. तुलादीषु for (तुलादिषु)
 ३. "सभाद्धा" लुप्त ५. भुक्तलिप्ताः for (भुक्तलिप्तावा)

- (ङ) ६. शोध्य for (विशोध्य)

३१. (घ) १. लग्नकला (ग) (च) (ङ) for (लग्नकाला)
 २. यद्यूनाः (ग) (च) (ङ) for (यद्यूना)
 ३. सचकालिप्ता (ग) (ङ) for (सचकालिप्ता)
 ४. राश्रयदयैः (ग) राश्रयदयैः for (स्वराश्रयदयैः)

- (ग) ५. दिना for (विना)

- (च) ३. सचकालिप्ताः for (सचकालिप्ता) ४. स्वराश्रयदयैः for (स्वराश्रयदयैः)
 ६. भवंत्यर्कं for (भवंत्यर्क)

- (ङ) ४. स्वराश्रयदयैः for (स्वराश्रयदयैः) ७. रंतते for (रंतर)

३२. (घ) १. यमाः (ग) (च) (ङ) for (यमा)
 २. शून्य (ग) (च) (ङ) for (शून्यगुणा)
 ३. कालीना (ग) (च) (ङ) for (कालीना) ४. रूनाः (च) for (रूना)
 ५. व्यस्तैः (ग) (च) (ङ) for (व्यस्तैः)

- (ग) ६. विपरीताः (ङ) for (विपरीता)

- (च) ६. विपरिताः for (विपरीता)

व्यस्ता^१ चा जादीनां^२ कलांशलग्नमिष्टघटिकांशः ।
 लग्ना घटिकाः कालांशै^४ विनैवं^५ स्वराश्युदयैः ॥ ३३ ॥
 इष्टार्कं^४ चराद्धं^२ ज्या क्षयवृद्धिज्याद्युरात्रिदलगुणिता ।
 व्यासाद्धेन विभक्ता क्षितिजा द्वादशगुणा भक्ता ॥ ३४ ॥
 क्रांत्याविषुवच्छाया क्षितिजेष्ट क्रांतिवर्णयोगं पदम् ।
 अग्रे^२ क्षितिजापक्रमजीवे त्रिज्या गुणोभक्ता ॥ ३५ ॥
 अर्काग्रयाक्षकलंबकजीवे दिनकृतचरासुविज्ञाने ।
 अर्कज्ञाने^२ ज्ञाने विषुवच्छाया चराभूनाम् ॥ ३६ ॥

३३. (घ) १. व्यस्तश्चाजादीनां (ग) (च) (ङ) for (व्यस्ताचाजादीनां)
 २. कालांशा (ग) कालांशौ for (कलांश)
 ३. लग्नाघटिकाः (ग) (च) (ङ) for (लग्नाघटिकाः)
 ४. कालांशकै (ग) (च) (ङ) for (कालांशै)
 ५. विनैवं (ग) (च) (ङ) for (विनैवं)
 ६. स्वराश्युदयैः (ग) (च) (ङ) for (स्वराश्युदयैः)
 (च) २. कालांश for (कलांश) (ङ) २. काजांशैर्लग्न for (कलांशलग्न)
 ३४. (घ) १. क्षयं for (क्षय)
 (ग) २. चराद्धंज्या (ङ) for (चराद्धंज्या) ३. गुणिताः for (गुणिता)
 (च) ४. इष्टार्कं for (इष्टार्कं) २. द्याक्षय for (ज्याक्षय)
 (ङ) ५. द्युरात्रदल for (द्युरात्रदल)
 ३५. (घ) १. वर्गयोगपदम् (ग) (च) (ङ) for (वर्गयोगपदम्)
 २. अग्न्या (ग) अग्रा for (अग्रे) ३. जीव (ग) जीवा for (जीवे)
 ४. गुणोभक्ते (ग) (च) (ङ) for (गुणोभक्ता)
 (च) २. अग्रक्षिति for (अग्रेक्षिति) ३. जीवत्रीज्या for (जीवेत्रिज्या)
 (ङ) १. वर्गयोगपदम् for (वर्गयोगपदम्) २. अग्रा for (अग्रे)
 ३६. (घ) १. कृच्चरा for (कृतचरा) (ग) दिनकृच्चरासुविज्ञाते for (दिनकृतचरासुविज्ञाते)
 २. अर्का (ग) for (अर्क) ३. चराभूनाम् (ग) (ङ) for (चराभूनाम्)
 ४. 'क' यहाँ 'क' लुप्त है (च) (ङ) ५. ज्ञाते ज्ञाते for (ज्ञाने ज्ञाने)
 (च) ६. अर्काग्रि for (अर्काग्र) ४. लंबक for (कलंबक)
 १. दिनकृच्चरा for (दिनकृतचरा) २. अर्कज्ञाने for (अर्कज्ञाने)
 ३. चराभूनां for (चराभूनाम्)
 (ङ) ६. अर्काग्रयाक्ष for (अर्काग्रयाक्ष) १. कृच्चरासु for (कृतचरासु)
 २. अर्कज्ञाने for (अर्कज्ञाने) ७. विषुवच्छाया for (विषुवच्छाया)

अष्टचरार्द्धस्य^१ ज्या क्षयवृद्धि^३ ज्यातदर्कवधकृत्या^२ ।
 त्रिज्याविषुवच्छाया^४ वधवर्गो^५ युतवधछेदः ॥ ३७ ॥
 व्यासार्द्धकृते^३ मूलं क्रांतिज्यावासदलगुणा^२ भक्ता ।
 जीनभागजीवया^२ लब्धचापमर्कपादैः^५ प्राग्वत् ॥ ३८ ॥
 विषुवच्छाया^२ भक्ता स्वचरार्द्धज्येष्टया^३त्यया भक्ता गुणिता ।
 लब्धस्य^३ चापमिष्ट^३ छायायाश्चरदलप्राणाः ॥ ३९ ॥
 स्वचरार्द्धज्याभक्ता^३ विषुवच्छायेष्ट^४ चरदल^२ श्रुनाम् ।
 गुणिताज्येष्ट^३ चरदल विषुवच्छाया^४ फलं भवति ॥ ४० ॥

३७. (घ) १. चरार्धस्य (ग) इष्टचरार्द्धस्य for (अष्टचरार्द्धस्य) ।
 २. कृत्याः (ग) कृत्या for (कृत्या) ३. वधवर्गो for (वधवर्गो)
 ४. हताछेदः (घ) हतछेदः for (युतवधछेदः)
 (ग) १. अष्टचरार्द्धस्य ज्या for (अष्टचरार्द्धस्य ज्या) २. कृत्या for (कृत्या)
 ४. हतछेदः for (वधछेदः)
 (ङ) १. इष्टचरार्धस्य for (अष्टचरार्द्धस्य) ५. विषुवच्छाया for (विषुवच्छाया)
 ४. युतहृतछेदः for (युतवधछेदः)
 ३८. (घ) १. कृतेर्मूलं (ग) भुक्तेर्मूलं for (कृतेर्मूलं) २. व्यास (ग) (ङ) for (वास)
 ३. जिन (ग) (च) (ङ) for (जीन) ४. मर्कः for (मर्क)
 ५. पादैः (ग) (ङ) for (पादैः)
 (ग) ६. लब्धं for (लब्ध)
 (च) १. कृते for (कृते) ४. मर्कः for (मर्क)
 (ङ) १. कृतेर्मूलं for (कृतेर्मूलं)
 ३९. (घ) १. व्यया गुणिता (ग) न्यया गुणिता for (त्यया भक्ता गुणिता)
 (च) १. ज्येष्ठयान्यया गुणिता for (ज्येष्ठयात्ययाभक्ता गुणिता)
 (ङ) २. विषुवच्छाया for (विषुवच्छाया) १. ज्यया for (त्यया)
 ३. मिष्टच्छायाया for (मिष्टच्छायाया)
 ४०. (घ) १. चरार्द्धज्या (ग) व्यचरार्द्धज्या for (चरार्द्धज्या)
 २. चरदलाश्रुनाम् (ग) (ङ) for (चरदलश्रुनाम्)
 (ग) ३. ज्ययेष्ट for (ज्ययेष्ट)
 (च) २. चरदलाश्रुनां for (चरदलश्रुनाम्) ३. छेष्ट for (ज्येष्ट)
 (ङ) १. चरार्धज्या for (चरार्द्धज्या) ३. ज्ययेष्ट for (ज्येष्ट)
 ४. विषुवच्छायेष्ट for (विषुवच्छायेष्ट)
 ५. विषुवच्छाया for (विषुवच्छाया)

मध्यमच्छायाग्रमुदक् शंकुतलादक्षनतभागः ।

दक्षिणतो यदि सौम्याः स्वाक्षांशा सर्वदा याम्याः ॥ ४१ ॥

द्युदलनतोक्षांशानामेक दिशानामंतरं युतिर्भेदे ।

क्रांत्यंशाः प्राग्वदिनः क्रांत्यंशोरेव मक्षांशाः ॥ ४२ ॥

उदये ज्येष्ठपक्रम जीवा कृत्यंतरात्पदं क्षितिजा ।

व्यासार्द्धं गुणा क्षितिजा भक्तोदयजिवया कक्षः ॥ ४३ ॥

४१. (घ) १. मध्यच्छाया (ग) for (मध्यमच्छाया)

२. तलादक्षिणो (ग) तलादक्षिणोनतभागाः for (तलादक्षिणा नता भागाः)

३. नता (ङ) for (नता)

४. भागाः (ङ) (भागः)

५. स्वाक्षांशाः (च) (ङ) for (स्वाक्षांशा)

(ग) ६. दक्षिणतो for (दक्षिणतो)

७. याम्या for (याम्याः)

(च) १. मध्यच्छायाग्रमुदक् for (मध्यमच्छायाग्रमुदक्)

६. दक्षिणतो for (दक्षिणतो)

(ङ) १. मध्यच्छाया for (मध्यमच्छाया)

२. दक्षिणा for (दक्ष)

४२. (घ) १. नतांशा शानामेक (ग) नतः क्षांशानामेक for (नतोक्षांशानामेक)

२. भेदो (ग) भेदै for (भेदे)

३. प्राग्वदिनः (ग) प्राग्वदितः for (प्राग्वदिनः)

४. क्रांत्यंशोरेव (ग) (च) (ङ) for (क्रांत्यंशोरेव)

(ग) ५. 'युति' लुप्त है

"क्रांत्यंशाः प्राग्वदितः" दो बार लिखा गया है ।

(च) १. द्युदलनतांशानामेक for (द्युदलनतोक्षांशानामेक)

३. प्राग्वदिनः for (प्राग्वदिनः)

(ङ) १. नतांशानामेक for (नतोक्षांशानामेक)

६. दिशामन्तरं for (दिशानामन्तरं)

३. प्राग्वदिनः for (प्राग्वदिनः)

४३. (घ) १. उदय (ङ) for (उदये)

२. क्षितिजाल्पा for (क्षितिजा)

३. जीवयाक्ष्या (च) for (जिवयाक्षः)

(ग) 'म' लुप्त

४. पक्षज्यात् शेषाः ॥४३॥ for (कक्षः)

(च) ३. जीवयाक्ष्या for (जिवयाक्षः)

(ङ) ५. व्यासार्द्धं for (व्यासार्द्ध)

३. जीवयाक्ष्या for (जिवयाक्षः)

उदय^२ ज्ययाविभक्ता क्रांतिज्या व्यासगुणालंबः^४ ।
 द्वादशगुणिता क्षितिजा विषुवच्छाया^५ हूता^१ क्रान्तिः ॥ ४४ ॥
 यष्टिव्यासाद्धैराप्राच्यपरा भास्करांतरांशज्या ।
 द्विगुणमुदया^३ सूत्रं^४ तत्त्रिज्या^५ कृतिविशेषपदम् ॥ ४५ ॥
 द्युदले^६ शंकु न तज्ये प्राच्यपराया यदि स्थितः शंकुः ।
 उदगूना दक्षिणतः^७ स्तदंतरेणाधिकार्काग्रा ॥ ४६ ॥
 उत्तरगोले^८ न तदं याम्य गोले सूर्ये ।
 शंकुतल शंकु^९ हूतं^{१०} विषुवच्छाया द्विषट्क गुणम् ॥ ४७ ॥

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४४. (घ) १. हूता (ग) (च) for (हूता)
 (ग) २. ज्यया for (ज्यया) ३. + दल + (ङ) (च)
 ४. लब्धाम् for (लम्बः)
 (ङ) ५. विषुवच्छाया for (विषुवच्छाया)
४५. (घ) १. ऽग्रा (च) for (ग्रा)
 (ग) २. 'तरां' पद लुप्त है
 ३. मुदयास्तसूत्रं (ङ) for (मुदयामूत्रम्)
 ४. क्रांति for (कृति)
 (च) २. ज्याः for (ज्या)
 (ङ) १. व्यासार्धेऽग्रा for (व्यासाद्धैरा)
४६. (घ) १. दक्षिणत (ग) for (दक्षिणतः)
 २. ऽधिका for (धिका)
 (ग) ३. द्युदले for (द्युदले) ४. शंकुतज्ये for (शंकुनतज्ये)
 ५. उदगूना for (उदगूना) ६. काकाग्रा for (कार्काग्रा)
 (च) ७. तल्ले for (तज्ये) १. दक्षिणांत for (दक्षिणतः)
 ६. ऽधिकावर्काग्रा for (धिकावर्काग्रा)
 (ङ) १. दक्षिणत for (दक्षिणतः)
४७. (घ) १. गोलेग्रो (ग) उत्तरगोलेग्रो for (उत्तर गोले)
 २. तलं (ग) (ङ) for (तल)
 ३. हूतं (ग) (ङ) (च) for (हूतं)
 (ग) ४. मंतदंतरं for (नं तदंतरं) ५. गोले for (गोले)
 (च) १. गोलेग्रो for (गोलेनं) ३. तदंतरं for (तदं)
 ७. विषुवच्छाया for (विषुवच्छाया)

शंकुतलशंकुगणिते त्रिज्ये तद्वर्गयुतिपदविभक्ते ।
 अक्षावलंबज्ये द्युदलस्थेऽर्कन्यदा द्युदलात् ॥ ४८ ॥
 छायावृत्तेऽर्कग्रा कर्णगुणा व्यासदल हृतार्कग्रा ।
 प्राच्यपरा शंकवन्तरमुत्तरयाम्यं तदून युता ॥ ४९ ॥
 उत्तर गोले याम्ये विषुवच्छायाग्रयांतरं हीनम् ।
 एवं विषुवच्छाया युक्तिविहीनांतरेणाग्रा ॥ ५० ॥
 बाहुक्रांतिः कोटिः क्षितिजातद्वर्गयुतिपदं कर्णः ।
 अग्रोदयास्त सूत्रादक्षिणतो द्रश्य शंकु तलम् ॥ ५१ ॥

४८. (घ) १. तद्वर्ग for (तद्वर्ग)

२. अक्षावलंबज्ये (ग) अक्षावलंबकज्ये (ङ) for (अक्षावलंबज्ये)

३. ऽर्कऽन्यदा (ग) स्छेऽर्केन्यद for (ऽर्कन्यदा)

(ग) ४. द्युदलात् for (द्युदलात्)

(च) १. तद्वर्ग for (तद्वर्ग) २. अक्षावलंबकज्ये for (अक्षावलंबज्ये)

३. ऽर्कऽन्यदा for (ऽर्कन्यदा)

(ङ) ३. ऽर्कऽन्यदा for (ऽर्कन्यदा)

४९. (घ) १. वृत्तऽर्कग्रा (ग) (ङ) for (वृत्तेऽर्कग्रा)

२. हृता for (हृता)

(ग) ३. शंकुतर for (शंकवन्तर) ४. तदून for (तदून)

५. युतम् for (युता)

(च) १. छायावृत्तेऽर्कग्राकर्ण for (छायावृत्तेऽर्कग्राकर्ण)

२. हृतार्कग्रा for (हृतार्कग्रा) ४. तदूना for (तदून)

(ङ) २. हृतार्कग्रा for (हृतार्कग्रा)

५०. (घ) १. युक्त (ग) (च) (ङ) for (युक्ति)

(ग) २. विहीनां वा रणाग्रा (विहीनांतरेणाग्रा)

(ङ) ३. विषुवच्छाया for (विषुवच्छाया) ४. अग्रयान्तरं for (अग्रयांतरं)

५. विषुवच्छाया for (विषुवच्छाया)

२. विहीनाज्जरेणा for (विहीनांतरेणाग्रा)

५१. (घ) १. द्रश्य (ग) for (द्रश्य)

(ग) २. क्षितिजां for (क्षितिजा)

३. अग्रोदयास्त for (अग्रोदयास्त)

४. दक्षिणतो for (दक्षिणतो)

१. द्रश्य (ङ) for (द्रश्य)

(ङ) १. बाहु. for (बाहु)

त्रिज्याक्षयवृद्धिर्द्यं कांतर मुदगितरयोर्दिनाद्धा^२त्या ।
 व्यासार्द्धचरा^३र्द्ध ज्यांतर संयोगोर्द्धरात्रा^३न्त्या ॥ ५२ ॥
 उक्रमजीवा चापं क्रमजीवाचापसहितमधिकं यत् ।
 दिनरात्र्यर्द्ध प्राणाः पृथग्दिना^५ चरदलप्राणैः ॥ ५३ ॥
 दिवसा^३र्द्धोत्क्रमजीवाधिकक्रमज्याधिकादिना^३र्द्धत्या ।
 व्यासार्द्ध दिना^३र्द्ध्यांतर चरज्याक्षयजीवातः ॥ ५४ ॥

५२. (घ) १. द्यैक्यांतर (ग) ज्यैक्यांतर for (द्यैकांतर)
 (ग) २. दिनाद्धा^३ for (दिनाद्धा^३त्या) ३. दिनाद्धं for (चराद्धं)
 ४. ज्यांतरं for (ज्यांतर) ५. संयोगोर्द्धं for (संयोगोर्द्धं)
- (च) २. दिनाद्धा^३त्या for (दिनाद्धा^३त्या)
- (ङ) १. ज्यैक्यान्तर for (द्यैक्यान्तर) २. दिनार्धान्त्या for (दिनाद्धा^३त्या)
 ३. व्यासार्धं चरार्धं for (व्यासार्द्धं चराद्धं)
 ५. संयोगोर्द्धरात्र्यन्त्या for (संयोगोर्द्धं रात्रा^३न्त्या)
- ५३ (घ) १. उत्क्रम (ग) (च) for (उक्रम)
 (ग) २. तीवा for (जीवा) ३. मधीकं चेत् for (मधिकं यत्)
 ४. विमा for (दिना)
- (ङ) १. उत्क्रम for (उक्रम) ५. चेत् for (यत्)
 ४. पृथग् विना for (पृथग्दिना)
५४. (घ) १. नाद्धा^३त्या (ग) (च) for (नाद्धा^३त्या)
 २. त्यांतरं (ग) (च) for (त्यांतर)
- (ग) ३. दिवासा^३र्द्धोत्क्रम for (दिवसा^३र्द्धोत्क्रम) ४. ज्याया for (ज्या)
 ५. 'य' लुप्त है (ङ)
- (च) ५. चरद्याक्षजीवातः for (चरज्याक्षयजीवातः)
- (ङ) ३. दिवसा^३र्द्धोत्क्रम for (दिवसा^३र्द्धोत्क्रम) ४. ज्याधिका for (ज्याधिका)
 १. दिनार्धान्त्या for (दिनाद्धा^३त्या)
 २. व्यासार्धं दिना^३र्द्धा^३न्त्यान्तरं for (व्यासार्द्धं दिनाद्धा^३त्यांतर)
 ५. क्षयजीवातः for (क्षयजीवातः)

स्वाहोरात्रार्द्धसम^१ यत्राक्षज्याबलंबकः^२ ।

क्रान्त्या^३ ह्येषा^४ दिगम्यता^५ वद्यावत्^६ कर्क्यादिगस्य^७ लेः ॥ ५५ ॥

नास्तमयस्तत्र तुला^८ मकरादिस्थस्य^९ नोदयोर्कस्य^{१०} ।

तन्मध्यांतरलिप्ता^{११} मध्यमभुक्त्या^{१२} हुता^{१३} दिवसाः^{१४} ॥ ५६ ॥

कोणच्छाया^{१५} कृतिदल^{१६} यदविषुवच्छायाया^{१७} रुदानृतबलं^{१८} प्राच्य^{१९} परयोः^{२०} ।

यद्यैक्यंतरं^{२१} याम्यदिक्स्थं^{२२} चेत् ॥ ५७ ॥

५५. (घ) १. समा (ग) for (सम)

२. ज्याबलंबकः क्रान्त्या for (ज्याबलंबकः क्रान्त्या)

३. यह पद 'पहली पंक्ति के अन्त में है ।

४. मेषादिगस्य (ग) for (ह्येषा दिगम्यता)

५. तावद्यावत् for (वद्यावत्) ६. कर्क्यादिगस्य for (कर्क्यादिगस्य)

(च) १. समा यात्रा for (सम यत्र) ४. मेषादिगस्य for (ह्येषादिगम्य)

६. कर्क्यादिगस्य for (कर्क्यादिगस्य)

(ङ) १. रात्रार्द्धसमा for (रात्रार्द्धसम)

३. 'क्रान्त्या' यह शब्द पहली पंक्ति का अन्तिम है ।

४. ५. मेषादिगस्य तावद्यावत् for (ह्येषा दिगम्यता वद्यावत्)

५६. (च) १. नोदयोर्कस्य (ग) नोदयोर्कस्य for (नोदयोर्कस्य)

२. हुता (ग) (ङ) for (हुता)

(ग) ३. सूत्रतुला for (स्तत्र तुला) ४. छस्य for (स्थस्य)

(च) १. नोदयोर्कस्य for (नोदयोर्कस्य) २. हुता for (हुता)

(ङ) १. नोदयोर्कस्य for (नोदयोर्कस्य)

५७. (घ) १. पद (ग) (च) (ङ) for (यद) २. रुदानृतलं (ग) (ङ) for (रुदानृतलं)

वि० श्लोक की पहली पंक्ति समाप्त ।

३. 'प्राच्य परयोः' दूसरी पंक्ति के आरंभिक पद हैं (ग)

४. यद्यैक्यंतरं (ग) (च) (ङ) for (यद्यैक्यंतरं)

(ग) ५. छायायो for (छायाया) ३. प्राच्य पराया (ङ) for (प्राच्यपरयोः)

वि० दूसरी पंक्ति का आरम्भ ।

६. स्थ for (स्थं)

(च) ७. कृतिदल (ङ) for (कृतिदल) २. रुदानृतबलं for (रुदानृतबलं)

(ङ) ८. कोणच्छाया for (कोणच्छाया) ५. विषुवच्छायायो for (विषुवच्छायाया)

कोणच्छायाकरणेन भक्तमवलंबकेन संगुणितम् ।
 इष्टापक्रमजीवा त्रिप्रश्नोक्त्या स्फुटोक्तैः ॥ ५८ ॥
 मध्यमगति स्फुटगति त्रिप्रश्नात् सोत्तरान् विजानाति यः ।
 स भवत्याचार्यो ब्रह्मोक्ता ज्ञानतंत्रज्ञाः ॥ ५९ ॥
 अध्यायः पंचदशस्त्रिप्रश्नस्योत्तरं यदिह नोक्तम् ।
 आर्याषिष्टोक्तं तद्गोलादुत्प्रेक्ष्य बुद्धिमता ॥ ६० ॥
 इति ब्रह्म गुप्ते त्रिप्रश्नाध्यायः
 पंचदश अध्यायः समाप्तः

५८. (ङ) २. कोणच्छाया for (कोणछाया) १. स्फुटः for (कोतः)

५९ (घ) १. 'यः' दूसरी पंक्ति का पहला पद है ।

२. तंत्रज्ञः (च) for (तंत्रज्ञाः)

(ग) ३. मध्यगतिः for (मध्यमगति)

४. स्पष्टगतिः for (स्फुटगति) १. 'यः' लुप्त है

५. वै ब्रह्मोक्तानान्य तंत्रज्ञा for (ब्रह्मोक्ताज्ञानतंत्रज्ञाः)

(ङ) ३. मध्यगति for (मध्यमगति) ४. स्पष्टगति for स्फुटगति)

६. त्रिप्रश्नान् for (त्रिप्रश्नात्) १. 'यः' लुप्त ।

५. ब्रह्मोक्तान् for (ब्रह्मोक्ता) २. योऽन्यतंत्रज्ञः for (ज्ञानतंत्रज्ञाः)

६०. (घ) १. यदिह (ग) (ङ) for (यदीह) २. दुप्रेक्ष्य for (दुत्प्रेक्ष्य)

३. बुद्धिमताः for (बुद्धिमता)

वि०—४. 'इति' से आरंभ कर 'समाप्त' तक मूल में लुप्त है ।

(ग) ५. त्रि for (स्त्रि) ६. तच्चायाषिष्टो यं for (आर्याषिष्टोक्तं)

४. इति ब्रह्मसिद्धांते त्रिप्रश्नोत्तर पंचदशोऽध्यायः for (इति ब्रह्मगुप्ते त्रिप्रश्नाध्यायः)

(च) १. यदिह for (यदीह)

४. 'इति' से 'समाप्तः' तक समस्त लुप्त

(ङ) १. तच्चायाषिष्टोऽयं for (आर्याषिष्टोक्तं)

२. गोलादुत्प्रेक्ष्य for (तद्गोलादुत्प्रेक्ष्य)

अथ ग्रहणोत्तराध्यायः

षोडशः

ग्रहणग्रहसंयोगग्रहः क्षीयोगेषु सर्वतन्त्रविदाम् ।
 आचार्यछेद्यक विद्यतस्ततः छेदकं वक्षे ॥ १ ॥
 दुर्जनकृतघ्नशत्रु प्रतिकंचुक करिपतितमुख्येभ्यः ।
 छेदकमदेयभ्योददतः सुकृतायुषोर्नाशः ॥ २ ॥
 उषिताय दीर्घकालशिष्याय गुणान्विताय भक्ताय ।
 आत्रे वास्तुह देवा सुताय वा छेदकं देयम् ॥ ३ ॥

१. (घ) १. ग्रह (ङ) (ग) for (ग्रहः) २. छेद्यकं (च) (ङ) for (छेदकं)

(ग) ३. क्षतत्रेषु for (क्षीयोगेषु) ४. 'तन्त्र' लुप्त है, (ङ)

५. आचार्यः for (आचार्य) ६. छेदक for (छेद्यक)

७. तत् for (ततः) ८. वक्ष्ये (ङ) for (वक्षे)

(ङ) ३. क्षतत्रेषु for (क्षीयोगेषु) ५. आचार्यश् for (आचार्य)

७. ततश् for (ततः)

२. (घ) १. कारि (ग) (ङ) for (करि) २. मूर्खेभ्यः (ग) for (मुख्येभ्यः)

३. छेद्यक (ग) (ग) (ङ) for (छेदक) ४. यमेभ्यो (ग) (ङ) for (यभ्यो)

५. नाश (ग) नाशः for (नाशः)

(ग) ६. दहतः for (ददतः)

(च) १. कारिपतित for (करिपतित) २. मूर्खेभ्यः for (मुख्येभ्यः)

४. मदेयमेभ्यो for (मदेयभ्यो)

(ङ) २. मुख्येभ्यः for (मुख्येभ्यः)

३. (घ) १. दीर्घकालं (ग) (च) (ङ) for (दीर्घकाल)

२. सुहृदेवा (ग) for (स्तुहृदे) ३. छेद्यकम् (च) (ङ) for (छेदकं)

(ग) ४. गुणाधिकाय (ङ) for (गुणान्विताय)

(च) २. वासुहृदेवा for (वास्तुहृदेवा)

(ङ) ५. पात्रे for (आत्रे) २. सुहृदे वा for (स्तुहृदे वा)

विषुवदयमंडलदिशो बलनज्याभि ग्रहास्त्रिग्रहवृत्ते ।
 संपर्कं ग्राह्यावायो वेत्ति छेदकज्ञः सः ॥ ४ ॥
 संपर्कमण्डले यः प्रग्रहमोक्षोपृथक् स्वविक्षेपात् ।
 मध्यान्मध्यग्रासं परिलिखित छेदकज्ञः सः ॥ ५ ॥
 परिलितीष्टग्रासं तत्कालिक बाहुकोटिकर्णो यः ।
 अथवा निमिलनोन्मीलनद्वयं छेदकज्ञः सः ॥ ६ ॥

४. (घ) १. वदपमंडल (च) (ङ) for (वदयमंडल)

२. ग्रहास्त्रि (ग) गृन्निग्रहवृत्ते for (ग्रहास्त्रिग्रहवृत्ते)

(ग) ३. ग्रास्यै for (ग्राह्य)

(च) २. ग्रहास्त्रिग्रहवृत्ते for (ग्रहास्त्रिग्रहवृत्ते) ४. छेदकज्ञः (ङ) for (छेदकज्ञः)

(ङ) २. भिस्त्रिग्रहवृत्ते for (भिग्रहास्त्रिग्रहवृत्ते) ५. संपर्कं for (संपर्कं)

३. ग्रासं for (ग्राह्य)

५. (घ) १. परिलिषिति (ग) पिरिलिषति for (परिलिखित)

(ग) २. मोक्षे for (मोक्षो) ३. प्रथक् for (पृथक्)

(च) ४. संपर्कं for (सम्पर्कं) १. परिलिषिति for (परिलिखित)

(ङ) २. मोक्षौ for (मोक्षो) १. परिलिखति for (परिलिखित)

५. छेदकज्ञः for (छेदकज्ञः)

६. (घ) १. परिलिषतीष्ट (ग) परिलिषतीष्ट (च) for (परिलितीष्ट)

२. कर्णयः (च) (ङ) for (कर्णोयः)

३. निमिलनोन्मीलन (ग) (च) for (निमिलनोन्मीलन)

४. छेदकज्ञः (च) (ङ) for (छेदकज्ञः)

(ग) ५. तात्कालिबाहुकोटि (ङ) for (तात्कालिकबाहुकोटि)

(च) ५. तत्कालि for (तत्कालिक)

(ङ) १. परिलिखतीष्ट for (परिलितीष्ट)

ग्राह्यं परिलिखितैक्यं परिलिखति ग्रहादिकं तत्र ।

भूमौ यफलके वा पर्वतं छद्म(द्य)कज्ञः सः ॥ ७ ॥

देशान्तरं यथा द्रक् प्रग्रहणांतराद्विजानाति ।

यो रेखातोऽध्वानं पर्वेष्टदिनात् स तत्रज्ञः ॥ ८ ॥

योवेति राहुमार्गं तेनेष्टकालमिष्टकालाद्वा ।

ग्रासं ग्रासात्कालं जानाति छेद्यकज्ञः सः ॥ ९ ॥

व्यासप्रमाणयोगग्राह्यग्रहाकदलानि चलनाद्या ।

विक्षेपाश्चापरतः पभृतिखे पूर्वतः शशिनः ॥ १० ॥

७. (घ) १. परिलिख्यैकं (ग) परिलेख्यैक्यं (ङ) for (परिलिखितैक्यं)
 २. लिपति (ग) for (लिखति) ३. प्रग्रहादिकं for (ग्रहादिकं)
 ४. पर्वत्तं (ग) परिवर्त्यं (ङ) for (पर्वतं)
 ५. छेद्यकज्ञः (ग) छेदकज्ञः for (छद्यकज्ञः)
 (ग) ६. यः (ङ) for (य)
 (च) १. परिलिख्यैकं for (परिलिखितैक्यं) ४. पर्वत्तं for (पर्वतं)
 ५. वछेद्यकज्ञः for (छद्यकज्ञः)
 (ङ) ३. ग्रहग्रहादिकं for (ग्रहादिकं) ५. च्छेद्यकज्ञः for (छद्य(द्य)कज्ञः)
 ८. (घ) १. यथागत (ग) ययागत for (यथा)
 २. द्रक्प्रग्रहणां (ग) for (द्रक्प्रग्रहणांतरा)
 ३. अध्वानं (ग) (च) (ङ) for (ध्वानं) ४. पर्वेष्ट (च) for (पर्वेष्ट)
 ५. तत्रज्ञः (ग) (ङ) for (तत्रज्ञः)
 (ग) ६. योरेखातो for (योरेखातो)
 (च) १. यथागत for (यथा) २. द्रक्प्रग्रहणांतरा for (द्रक्प्रग्रहणांतरा)
 (ङ) १. यथागत for (यथा) २. द्रक् for (द्रक्)
 ९. (घ) १. वेति (च) (ङ) for (वेति) २. वाः for (वा)
 (ग) ३. ग्रास (ङ) for (काल) ४. छेदकज्ञः for (छद्य(द्य)कज्ञः)
 (च) ३. ग्रास for (काल) २. मिष्टकालाद्वाः for मिष्टकालाद्वा
 (ङ) ४. च्छेद्यकज्ञः for (छद्य(द्य)कज्ञः)
 १०. (घ) १. ग्राहक (ग) (ग) (ङ) for (ग्रहाक)
 २. चलनद्या (ग) चलनज्या for (चलनाद्या) ३. रवेः (ग) (च) (ङ) (रवे)
 (ग) ४. प्रभृति for (पभृति) (च) २. चलनद्यां for (चलनाद्या)
 (ङ) ५. ग्रास for (व्यास) २. चलनज्या for (चलनाद्या)
 ६. विक्षेपाश्चापरतो for (विक्षेपाश्चापरतः) ४. भवति for (प्रभृति)

दिनदलविभक्तजित्तगुणदिनगतशेषाल्पजीवयेष्टगुणम् ।
 त्रिज्यार्द्धमधिकमंगुललिप्तास्त्रिग्रहज्यया भक्तम् ॥ ११ ॥
 योनचेत्या द्वितया द्वितया दंगुललिप्ता स्त्रिसंगुणाष्टहतात् ।
 ज्याद्वितीययुक्तिभक्तात्तद्विषुष यवो दरैः षडभिः ॥ १२ ॥
 व्यास वलनापर्वन मेकेनेष्टेना चार्यमितरेषाम् ।
 अंगुलकलाभिरेवं शशिसितपरिलेख सूत्राणाम् ॥ १३ ॥

११. (घ) १. जिन (ग) (च) (ङ) for (जित्त) २. त्रिग्रह (च) for (स्त्रिग्रह)
 (ग) ३. जीवयेषु (ङ) for (जीवयेष्ट) ४. तृज्यार्द्ध for (त्रिज्यार्द्ध)
 ५. मंडल for (मंगुल)
 (ङ) ४. त्रिज्यार्द्ध for (त्रिज्यार्द्ध)
- १२ (घ) १. चेत्पाद्वितया for (चेत्पाद्वितयाद्वितया)
 २. हतात् (ग) स्त्रिहतात् for (हतात्)
 ३. द्वितय (ग) for (द्वितीय)
 ४. यवोदारैः (ग) यवोदरैः (ङ) for (यवोदरैः)
 (ग) ५. ज्योना for (योन) १. चेज्याद्वितीयदंगुल for (चेत्पाद्वितया द्वितया)
 ६. भक्तात् (ङ) for (भक्तात्) ७. विषुषक for (द्विषुष)
 (च) १. चेनत्याज्या for (चेत्पाद्वितया) ५. ज्योना for (योन)
 (ङ) ५. ज्याना for (योन) ७. द्वितीय for (द्वितयाद्वितया)
 ८. संगुणात् for (संगुणाष्ट) २. त्रिहतात् for (हतात्)
 ३. ज्याद्वितीययुक्ति for (ज्याद्वितीययुक्ति)
१३. (घ) १. वलनापर्वत्तन (ग) वलनाप्रवर्त्तन for (वलनापर्वन)
 २. नवार्य for (नाचार्य) (ग) न कार्यमीतरेषाम् for (नाचार्यमितरेषाम्)
 ३. परिलेख (ग) (च) for (परिलेख)
 (च) १. पर्वत for (पर्वन) २. मेकेनेष्टेनवर्य for (मेकेनेष्टेनाचार्य)
 ४. नित for (सित)
 (ङ) १. वलनापर्वत्तन for (वलनापर्वन) २. मेकेनेष्टेन for (मेकेनेष्टेना)
 ५. कार्य for (चार्य)

प्रथमे वलनज्याभिर्द्वि^३शो द्वितीयं यथादिशं भानोः ।
 ग्राह्यतौ विक्षेपौ मध्यान्मध्योन्यथा शशिनः ॥ १४ ॥
 विक्षेपाग्रात् ग्राह्यं परिलिख्य ग्राहकप्रमाणेन ।
 प्रग्रहमोक्षग्रासामुपरिलेख भवंत्येवम् ॥ १५ ॥
 पश्चात्प्रग्रहो प्राग्मोक्षे रविबिम्बं मध्यतो बाहुः ।
 स्ववलन सिद्धायां दिशि विपरीतशीतकरणमध्यात् ॥ १६ ॥
 भानुमते बाह्वग्राद्यथा दिशं कोटिरन्यथा शशिनः ।
 रविशशिमध्यात् कर्णस्तिर्यक्कर्णाग्रकोटिगुते ॥ १७ ॥

१४. (ग) १. द्वितीये (ङ) for (द्वितीयं) २. राशिनः for (शशिनः)
 (ङ) ३. द्विशो for (द्विशो)
१५. (घ) १. विक्षेपाग्राद्ग्राह्यं (ग)विक्षेपाग्राह्यं for (विक्षेपाग्रात्ग्राह्यं)
 २. भूपरिलेखे (ग) भूपरिलेखे for (भूपरिलेख)
 (ग) ३. पिरिलिख्य for (परिलिख्य)
 ४. यहां 'प्रमाणेन' के साथ विसर्ग भी लगे हैं ।
 (च) १. विक्षेपाग्राद्ग्राह्यं for (विक्षेपाग्रात्ग्राह्यं)
 २. भूपरिलेखे for (भूपरिलेखे)
 (ङ) १. शशिविक्षेपाग्रम्यः ग्राह्यं for (विक्षेपाग्रात्ग्राह्यं)
 ३. परिलिख्य for (परिलिख्य) २. भूपरिलेखे for (भूपरिलेखे)
१६. (घ) १. पश्चात्प्रग्रहो (ग) पश्चात्प्रग्रहणात् for (पश्चात्प्रग्रहो)
 २. बिम्ब (ग) (च) (ङ) for (बिम्बं)
 ३. शीतकत (ग) शीतकरमध्यात् (ङ) for (शीतकरणमध्यात्)
 (ग) ४. प्राक् मोक्षे for (प्राग्मोक्षे) ५. सिद्धज्या (ङ) for (सिद्धायां)
 ६. विपरीतः (ङ) for (विपरीत)
 (च) १. पश्चात्प्रग्रहो for (पश्चात्प्रग्रहो)
 (ङ) १. पश्चात्प्रग्रहो for (पश्चात्प्रग्रहो)
१७. (घ) १. भानुमतो (ग) (च) (ङ) for (भानुमते)
 २. बाह्वग्रा (ग) (च) for (बाह्वग्राद्यथा)
 (ग) ३. कोटिरं for (कोटि) ४. तिर्यक्कर्णा for (तिर्यक्कर्णा)
 (ङ) १. भानुमतो for (भानुमते)

परिलेखं^१ ग्राह्यस्य ग्राहकमानेन पूर्ववत्कृत्वा ।
 तात्कालिकसंस्थानं निमीलनोन्मीलने चैवम् ॥ १८ ॥
 विक्षेपगुणत्रिज्या मानैक्याद्धौ^१ द्वा^२ ताप्तचापांशाः ।
 ग्राह्यंतयोर्यथादिशमर्कस्येदौ^२ विपर्यस्थाः ॥ १९ ॥
 तत्स्ववलनंशकयोगान्तर जीवाग्राह्यमानदलद्यातात् ।
 त्रिज्यालब्धज्याग्र^३ प्रग्रहमोक्षौ प्राग्वर्कद्वौ^४ ॥ २० ॥
 हुतया^५ व्यासाद्धेनार्कचन्द्रमानाद्धेलिप्तिका गुण्याया ।
 मध्यवलनछाया दक्षिणोत्तरा दिगतवामध्यात् ॥ २१ ॥

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१८. (घ) १. परिलेखं (ग) (च) for (परिलेखं)
१९. (घ) १. गुणा (ग) गुण्या for (गुण)
 २. मर्कस्येदौ (ग) (ङ) for (मर्कस्येदौ)
 ३. विपर्ययस्ता (ग) विपर्यस्ताः (ङ) for (विपर्यस्थाः)
- (च) १. गुणा for (गुण) २. मर्कस्येदौ for (मर्कस्येदौ)
 ३. विपर्ययस्ताः for (विपर्यस्थाः)
 १. विक्षेपगुणा for (विक्षेपगुण)
२०. (घ) १. वलनांशयोगान्तर (ग) (ङ) for (वलनांशकयोगान्तर)
 २. घातात् (च) (ङ) for (द्यातात्)
 ३. ग्र^० (च) (ङ) for (ग्र) ४. प्राग्वद्वर्कद्वौः (ग) for (प्राग्वर्कद्वौः)
- (च) १. वलनांशयोगान्तर for (वलनांशकयोगान्तर)
 ४. प्राग्वद्वर्कद्वौः for (प्राग्वर्कद्वौः)
- (ङ) ५. ग्रहमोक्षौ (प्रग्रहमोक्षौ) ४. प्राग्वद्वर्कद्वौः for (प्राग्वर्कद्वौः)
२१. (घ) १. लिप्तिका (च) for (हुतया) २. ज्याया (ग) for (छाया)
 २. दिगनया (ग) दिगमनया मध्या for (दिगतवा)
 (ग) ४. हुतव्यासाद्धेनार्क for (हुतयाव्यासाद्धेनार्क)
 (च) ४. हुतया व्यासाद्धेनार्क for (हुतया व्यासाद्धेनार्क)
 ३. दिगनया for (दिगतवा)
 (ङ) १. हुतया for (हुतया) ५. मध्यमवलनज्या for (मध्यवलनछाया)
 ३. दिगमनया for (दिगमया) ६. मध्या for (मध्यात्)

प्राग्वत् प्रसार्य^४ विक्षेपलिप्तिका^१ ग्राहकप्रमाणेन ।
 विक्षेपायाद्ग्राह्यं^१ परिलिख्य^२ ग्राह्यसंस्थानम्^३ ॥ २२ ॥
 त्रिज्या^४ विक्षेपगुणा^३ भक्तेष्टग्रासकर्णलिप्ताभिः ।
 प्राग्वत् फलचाप^३ स्ववलनांश^३ योगांतरं^३ तज्या ॥ २३ ॥
 मानार्द्धं^३ गुणाव्यासार्द्धं^३ भाजिता^३ पूर्ववत् प्रसार्या^४ स्यात् ।
 कर्णं^३ प्रसार्य^४ मध्यादग्रं^३ मध्येन^३ कर्णाग्रात्^३ ॥ २४ ॥
 तात्कालिकसंस्थानं^३ परिलिख्य^२ ग्राहकप्रमाणेन ।
 ग्राह्येन^२ मीलोन्मीलने^४ परिलेख^३ एवं वा ॥ २५ ॥

२२. (घ) १. विक्षेपाग्राद्ग्राह्यं (ग) for (विक्षेपायाद्ग्राह्यं)
 २. परिलिख्य (ग) परिलेख for (परिलिख्य)
 ३. ग्रास (ग) (च) (ङ) for (ग्राह्य)
 (ग) ४. प्राग्प्रसार्य for (प्राग्वत् प्रसार्य)
 (च) १. विक्षेपाग्राद्ग्राह्यं for (विक्षेपायाद्ग्राह्यं)
 २. परिलिख्य for (परिलिख्य)
 (ङ) १. विक्षेपाग्रात् for (विक्षेपायाद्)
२३. (घ) १. गुणाः (च) for (गुणा)
 (ग) २. व्यास for (ग्रास) ३. चार्था for (चाप)
 ४. यथाजिवा for (तज्या)
 (च) ५. त्रिज्या for (त्रिज्या) ४. तद्या for (तज्या)
 (ङ) ४. तथा जीवा for (तज्या)
२४. (ग) १. दग्रकर्णेन for (दग्रमध्येन) २. मध्याग्रात् for (कर्णाग्रात्)
 ३. ३+गुणा व्यासार्द्धं +
 (ङ) १. दग्रकर्णेन for (दग्रमध्येन) २. मध्याग्रात् for (कर्णाग्रात्)
२५. (घ) १. परिलिख्य (च) for (परिलिख्य)
 २. निमीलनोन्मीलने च (ग) नमीलनोन्मीलने च for (ग्राह्येन मीलो-
 न्मीलने च)
 (ग) ३. परिलेख for (परिलेख)
 (च) ४. +व+
 (ङ) २. एवं निमीलनोन्मीलने for (ग्राह्येन मीलोन्मीलने)
 ४. +च+

प्राच्यपरिविपरिते विपरीतं मध्यवलनमकेंद्रोः ।

पूर्वदन्यत् सर्वं फल कोष्ठौ ग्रहणपरिलेखः ॥ २६ ॥

दृग्गणितप्रग्रहयोरंतरघटीका फलं ग्रहे मध्यौ ।

देशांतरं धनं प्राक् प्रग्रहणे त क्षयः पश्चात् ॥ २७ ॥

प्रग्रहणांतर घटिकाभूपरिधिहता विभाजयेत् षष्ठ्या ।

फलयोजनेश्चवंत्या प्राग्वत् प्रागपरयोर्देशः ॥ २८ ॥

पातोनखेर्भाद्धात् चक्रोच्चोनाधिकाः कलाभक्ताः ।

तद्गतियुत्थाप्तदिने रासन्ने कंस्य मासांते ॥ २९ ॥

२६. (घ) १. विपरीते (ङ) for (विपरिते) २. फलकेष्टौ (ग) for (फलके स्वे)
 ३. परिलेखाः (ग) (च) (ङ) for (परिलेखः)
 (ग) ४. पार for (परि) ५. विपरितं for (विपरीतं)
 (च) ४. पर for (परि) १. विपरीते for (विपरिते)
 ५. मकेंद्रोः for (मकेंद्रोः) ७. स्थर्व for (सर्वं)
 २. फलकोष्ठौ for (फलकोष्ठौ)
 (ङ) ४. प्राच्यपरे for (प्राच्यपरि) ८. पूर्वदन्यत् for (पूर्वदन्यत्)
 २. फलके स्वे for (फलकोष्ठौ)
 २७. (घ) १. प्रग्रयो for (प्रग्रहयो) २. घटिका (च) for (घटीका)
 ३. मध्ये (ङ) for (मध्यौ) ४. तक्षयः for (तक्षयः)
 (ग) ५. फलग्रहमध्ये for (फलग्रहेमध्यौ) ६. 'त' लुप्त है ।
 (च) १. प्रग्रयो for (प्रग्रहयो) ३. मध्यो for (मध्यौ)
 (ङ) २. घटिका for (घटीका) ४. क्षयं for (तक्षयः)
 ७. +तत्+
 २८. (घ) १. योजनेष्ववंत्याः (ङ) for (योजनेश्चवंत्या)
 (च) १. योजनेष्ववंत्याः for (योजनेश्चवंत्या)
 २९. (घ) १. प्रतौनखेर्भाद्धा (ग) पातार्कयुतेर्भाद्धाच्च for (पातोनखेर्भाद्धात्)
 २. रासन्नेऽकंस्य for (रासन्नेकंस्य)
 (ग) ३. क्राद्धौ (घ) चक्राच्चौ for (चक्रोच्चौ)
 ४. कलाभक्ता (ङ) for (कलाभक्ताः) ५. मासांत्ये for (मासांते)
 (च) ३. चक्राच्चोनाधिकाः for (चक्राच्चोनाधिकाः) २. ऽकंस्य for (कंस्य)
 (ङ) १. पातार्क युतिर्भाद्धात् for (पातोनखेर्भाद्धात्)
 ३. चक्राच्चोनाधिका for (चक्रोच्चोनाधिकाः)
 २. रासन्नेऽकंस्य for (रासन्नेकंस्य)

पर्वदोः^१ पक्षांते प्रागाधिकोना^२ युतिर्भवति पश्चात् ।
 तन्मध्ये न ग्रहरां यदि भानोः पंच जिनभरसाः ॥ ३० ॥
 इंदोर्विषया^३ द्वितमा^४ दिवाकरा^५ त्रिविषयास्तदुच्चस्य ।
 व्योमातिधृतिद्वियुगानि^६ रसशरांश्चन्द्रपातस्य ॥ ३१ ॥
 खं नंदा^७ द्वियमाः^८ खाब्धयो^९ गृहाद्या^{१०} यथेष्ट^{११} पर्वगुणाश्चेप्याः ।
 पर्वाण्यप्यति^{१२} शोध्याः^{१३} पातेऽन्यथातीते ॥ ३२ ॥

- ३० (घ) १. पर्वदोः for (पर्वदोः) २. प्रागाधिको (ग) (च) for (प्रागाधिको)
 (ग) ३. रसा for (रसाः)
 (ङ) २. प्रागाधिकोना for (प्रागाधिकोना) ४. "युतिर्" लुप्त
- ३१ (ङ) १. द्वियमा (ग) (च) (ङ) for (द्वितमा)
 २. द्वियुगानि (ङ) द्वियुगानि for (द्वियुगानि)
 (ग) ३. विषया for (विषया) ४. त्रिविषया (ङ) for (त्रिविषया)
 ५. स्तदुच्चस्य । ५ । २२ । १२ । ४३ । for (स्तदुच्चस्य)
 ६. धृते for धृति
 ७. सरा- । १६ । ४२ । ५६ इन्द्र for (शरांश्चन्द्र)
 (ङ) ५. स्तदुच्चस्य । ५ । १२ । १२ । ५३ for (स्तदुच्चस्य)
 ७. रसशरांश्चन्द्रपातस्य ० । १६ । ४२ । ५६ । ३१ for (रसशरांश्चन्द्रपातस्य)
३२. (घ) १. गृहा (ग) (च) for (ग्रहा)
 २. क्षेप्याः (ग) for (क्षेप्याः) द्वितीय पंक्ति का आरम्भिक पद
 १. पर्वण्ये (ग) पर्वण्यप्यति for (पर्वाण्यप्यति)
 (ग) ४. 'ः' विसर्ग लुप्त है
 ५. खब्धयो ० । ६ । २२ । ४० for (खाब्धयो)
 १०. स्तथेष्ट for (यथेष्ट)
 ६. शोध्या मध्ये क्षतिक्रांते for (शोध्याः पातेऽन्यथातीते)
 ७. 'शोध्याः' से आगे के पद लुप्त हैं ।
 (च) २. पर्वगुणाः क्षेप्याः for (पर्वगुणाः क्षेप्याः)
 ३. पर्वाण्यप्यति for (पर्वाण्यप्यति)
 (ङ) ८. खं for (ख) ५. खाब्धयो ० । ६ । २२ । ४० for (खाब्धयो)
 १. गृहाद्या for (ग्रहाद्या) १०. स्तथेष्ट for (यथेष्ट)
 ६. गुणाः for (गुणा) वि० यहां श्लोकार्ध समाप्त
 २. क्षेप्याः for (क्षेप्याः) (वि० श्लोक की दूसरी पंक्ति का आरम्भ)
 ३. पर्वण्ये for (पर्वाण्यप्यति) ६. शोध्या for (शोध्याः)
 ७. मध्ये for (पाते) ११. त्वतिक्रांते for (अन्यथातीते)

गृहणे यथा रवीन्द्रोः स्पष्टीकरणाद्य मुक्तवत्कृत्वा^२
 एवं पर्वज्ञानं गृहणज्ञानं स्फुटं गणितात् ॥ ३३ ॥
 चत्वारि त्रयुवर्त्तं गृहणान्यकस्य सप्तचन्द्रस्य ।
 द्रष्टोदयास्तमययोर्कैरात्रिदलयोश्च केंद्रस्य ॥ ३४ ॥
 सर्वपादानामन्तो तिथ्यन्तज्ञानमिदुभास्करयोः ।
 गृहणे च कृते स्पष्टे जिष्णुसुतब्रह्मगुप्तेन ॥ ३५ ॥

३३. (ग) १. यथरविन्द्रोः for (यथा रवीन्द्रोः)
 २. ज्ञात्वा for (कृत्वा) ३. "गृहणज्ञानं" लुप्त पद है
 (च) ३. गृहणज्ञानस्फुटं for (गृहणज्ञानं स्फुटं)
 (ङ) २. मुक्तवत् ज्ञात्वा for (मुक्तवत् कृत्वा)
३४. (घ) १. त्रयुवर्त्तं (ग) त्रयुवर्त्त for (त्रयुवर्त्तं)
 २. गृहणान्यकस्य (ग) (च) (ङ) for (गृहणान्यकस्य).
 ३. द्रष्टो (ग) इन्द्रोदयास्त सनयायार्क for (द्रष्टोदयास्त)
 ४. शीतरश्मेश्च (ङ) for (सप्तचन्द्रस्य)
- (च) १. त्रयुवर्त्तं for (त्रयुवर्त्त) ३. द्रष्टो for (द्रष्टो)
- (ङ) १. चत्वारोऽत्रपर्त्तं for (चत्वारित्रयुवर्त्तं)
 ३. द्रष्टोदयास्त for (द्रष्टोदयास्त)
 ५. समया तथाऽर्कं for (मययोर्कं)
३५. (घ) १. मन्ते (ग) पदानामन्ते (च) for (पादानामन्तो)
 २. कृते (ग) चक्रते for (चक्रते)
- (घ) ३. तिथ्ये for (तिथ्यन्ते)
- (च) २. कृते (ङ) for (कृते)
- (ङ) १. सर्वपादानामन्ते for (सर्वपादानामन्तो)
 ३. तिथ्यन्ते for (तिथ्यन्ते)

दुरभ्रष्टे ग्रहणो^१ श्रेषेणार्यभटाविष्णुचन्द्रस्य^३ ।
 दृग्गणितविसंवादः काकतालीयम् ॥ ३६ ॥
 स्फुटतिथ्यंतज्ञानं यन्नार्यभटादिभिः कृतमतीतैः ।
 ब्राह्मे स्फुटं कृतं तज्जिष्णुसुतब्रह्मगुप्तेन ॥ ३७ ॥
 ब्रह्मोक्तोक्तैन्दु तदुच्चपातदेशांतरस्फुटीकरणैः ।
 स्फुटसिद्धकं ग्रहणद्वयं स्फुटमतीतोक्तम् ॥ ३८ ॥
 विक्षेपाग्रेषु त्रीन्बिन्दून् प्रग्रहणमध्यमोक्षेषु ।
 कृत्वा तन्मन्यद्वयमध्यगयोः सूत्रयोर्योगात् ॥ ३९ ॥

३६. (घ) १. दूरभ्रष्टे (च) (ङ) for (दुरभ्रष्टे)
 २. श्रीषेणार्य (ग) श्रेणार्य (ङ) for (श्रेषेणार्यभट)
 ३. चन्द्रेषु (ग) (च) (ङ) for (चन्द्रस्य)
 ४. विसंवादात्संवादः (च) for (विसंवादः)
 (ग) ५. ग्रहगणितविसंवादात्संवादः for (दृग्गणितविसंवादः)
 (च) २. श्रीषेणार्य for (श्रेषेणार्य)
 (ङ) ५. ग्रहगणित for (दृग्गणित) ४. विसंवादात् संवादः for (विसंवादः)
 ६. काकतालीयः for (काकतालीयम्)
३७. (घ) १. यन्नार्य for (यन्नार्य)
३८. (घ) १. सिद्धकं (घ) सिद्धकं for (सिद्धकं)
 (ग) २. ब्रह्मोक्तोक्तैन्दुस्तदुच्च for (ब्रह्मोक्तोक्तैन्दु)
 ३. स्फुटिकरणैः for (स्फुटीकरणैः) ४. द्वितयं न for (द्वयं)
 ५. स्फुटमतीतोक्तम् for (स्फुटमतीतोक्तम्)
 (च) २. ब्रह्मोक्ताक्तैन्दु for (ब्रह्मोक्तोक्तैन्दु) १. सिद्धकं for (सिद्धकं)
 (ङ) २. ब्रह्मोक्तोक्तैन्दु for (ब्रह्मोक्तोक्तैन्दु) १. सिद्धकं for (सिद्धकं)
 ४. ग्रहणद्वितयं for (ग्रहणद्वयं)
३९. (घ) १. कृत्वा for (कृत्वा)
 २. तन्मन्यद्वय (ग) तन्मन्यद्वय for (तन्मन्यद्वय)
 ३. मध्यमयोः for (मध्यगयोः)
 (च) १. कृत्वा for (कृत्वा) २. तन्मन्य for (तन्मन्य)
 (ङ) २. तन्मन्य for (तन्मन्य)

बिन्दु परिलेखरेखा ग्राहकमार्गः प्रसार्य सूत्रे द्वे ।
 आद्यन्ताभ्यां मध्यममाद्येद्य स्थूल एवं वा ॥ ४० ॥
 बिन्दु द्वयांतरं स्थितिदलेन हृतमिष्टनाडिकागुणितम् ।
 ग्राह्यफलंगुलस्थं ग्राहकमानेन परिलेखः ॥ ४१ ॥
 इष्ट ग्रासोर्कंदोर्निमीलनोन्मीलनं च भानुमतः ।
 त्रषुवर्तः प्राग्मध्यात् पश्चाद्विष्टांगुले स्थेन ॥ ४२ ॥

४०. (घ) १. परिलेखरेखा (ग) for (परिलेखरेखा)

२. माद्येद्य (ग) माद्येद्य for (माद्येद्य)

३. स्थूल (ग) (च) (ङ) for (स्थूल)

(च) १. परिलेखरेखा for (परिलेखरेखा)

(ङ) ४. मध्यम for (मध्यम) २. मुच्छाद्य for (माद्येद्य)

५. मेवं वा for (एवं वा)

४१. (घ) १. परिलिख्य (ग) परिलेखः for (परिलेखः)

(ग) २. बिन्दुद्वयान्तर for (बिन्दुद्वयांतरं) ३. हृत (च) (ङ) for (हृत)

४. नाडिका for (नाडिका) ५. छा for (स्थं)

(च) १. परिलिख्य for (परिलेखः)

(ङ) १. परिलिख्य for (परिलेखः) ६. ग्राह्य for (ग्राह्य)

४२. (घ) १. ञ्कंदो (ग) इष्टग्रासोर्कंदो for (इष्टग्रासोर्कंदो)

२. मीलने (ग) मिलने for (मीलनं)

३. त्रषुवर्तः (ग) (च) for (त्रषुवर्तः)

४. पश्चाद्विष्टांगुल (ग) (च) for (पश्चाद्विष्टांगुले)

(च) १. ञ्कंदो for (ञ्कंदो)

२. मीलने (ङ) for (मीलनं)

(ङ) १. ञ्कंदो for (कंदो)

५. भानुमतोः for (भानुमतः)

३. उर्वरितः for (त्रषुवर्तः)

४. पश्चाद्विष्टाङ्गुल for (पश्चाद्विष्टांगुले)

मध्यस्य^१ दिनांत्य^२ नवांतरं^३ मिष्टघटिकाभिः^४ ।
 स्थित्यर्द्धनाडिकाद्रतमृणधनमूनाधिके मध्ये ॥ ४३ ॥
 आद्यन्ते वाङ्कृत्वा^५ विक्षेपः^६ कोटिरूक्तवद्ग्रासः ।
 विक्षेपान्तरमेवं गुणमिष्टग्रासलिप्ताभिः^७ ॥ ४४ ॥
 मध्यग्रासकला हृतमृणधनं^८ चोक्तवत्स्वविक्षेपः^९ ।
 तेन ग्रासात्कालः^{१०} कालादसकच्च^{११} विक्षेपः ॥ ४५ ॥
 ग्रहणोत्तरं न देयं शपथैरपि दत्तं सुकृत्^{१२} नाशाद्यैः ।
 ग्रहणं स्फुटमिहास्फुटमार्यभटाद्यैर्यतस्तत्रैः^{१३} ॥ ४६ ॥

४३. (घ) १. मध्यस्याद्येनांत्ये (ग) मध्यस्याद्येनांते for (मध्यस्यदिनांत्य)
 २. गुणितमिष्ट (ग) गुणीतमिष्ट for (मिष्ट)
 ३. दृत (ग) हृत for (द्रत)
 (ग) ४. घटिभि for (घटिकाभिः) ३. धनमृण for (मृणधन)
 (च) १. मध्यस्याद्येनांत्यनवांतरं for (मध्यस्य दिनांत्य नवांतरं)
 २. गुणितमिष्टघटिकाभिः for (मिष्टघटिकाभिः) ३. हृत for (द्रत)
 (ङ) १. मध्यस्याद्येनान्तेन for (मध्यस्यदिनांत्य न)
 २. वाङ्तरं गुणित for (वांतरं) ३. हृत for (द्रत)
४४. (घ) १. विक्षे (ज्ञे) यः for (विक्षेपः)
 (ग) २. वा कृत्वा for (वाङ्कृत्वा) ३. विलिकाभिः for (लिप्ताभिः)
 (ङ) २. च पृषत्के for (वाङ्कृत्वा)
४५. (घ) १. हृतमृणधनं (ग) हृतमृणधन (च) for (हृतमृणधन)
 २. विक्षेण (ग) विक्षेपं for (विक्षेपः)
 ३. दसकृच्च (ङ) (च) for (दसकच्च)
 (ग) ४. वोक्त for (चोक्त) ५. ख for (स्व)
 ६. कालदसत्कृच्चविक्षेप for (कालादसकच्च विक्षेपः)
 (च) २. विक्षे for (विक्षेपः)
 (ङ) १. हृतमृणधनं for (हृतमृणधन)
४६. (ग) १. 'स्फुट' लुप्त है । २. 'मिहा' लुप्त है ।
 ३. तंतैः for (तंत्रैः)
 (च) ४. सुकृत for (सुकृत) १. स्पष्ट for (स्फुट)
 (ङ) ४. सुकृतनाशाय for (सुकृतनाशाद्यैः) २. मार्यभट for (मिहास्फुट)
 ५. श्रीवेणाद्यै for (मार्यभटाद्यै) ३. र्यतस्तत्र for (र्यतस्तत्रैः)

परिलेखो बलिनज्या विक्षेपाद्येषु षोडशोऽध्यायः ।

ग्रहणोत्तरमर्कद्वोः षट्चत्वारिंशदार्याणाम् ॥ ४७ ॥

इति श्री ब्रह्मगुप्ते ग्रहणाधिकारः

षोडशोऽध्यायः समाप्तः



४७. (घ) १. परिलेषो (ग) परिलेष for (परिलेखो)
२. षोडशोऽध्यायः (ङ) for (षोडशोऽध्यायः)
३. मर्कद्वो for (मर्कद्वोः)
४. 'इति' से 'समाप्तः' तक पाठ अंकित नहीं ।

- (ग) ५. बलन for (बलिन)
४. इति श्री ब्रह्मसिद्धान्ते ग्रहणोत्तराध्यायः षोडशः for (इति श्री ब्रह्मगुप्ते
ग्रहणाधिकारः षोडशोऽध्यायः समाप्तः)

- (च) १. परिलेषो for (परिलेखो) ५. बलनद्या for (बलिनज्या)
२. षोडशो for (षोडषो) ३. मर्कद्वो for (मर्कद्वोः)
४. 'इति' से 'समाप्तः' तक लुप्त ।

- (ङ) १. परिलेख for (परिलेखो) ५. बलनजीवा for (बलिनज्या)
४. इति श्री ब्राह्मस्फुट सिद्धान्ते ग्रहणोत्तराध्यायः षोडशः for (इति श्री ब्रह्म-
गुप्ते ग्रहणाधिकारः षोडशोऽध्यायः समाप्तः)

अथ शृङ्गोन्नत्युत्तराध्यायः

सप्तदशः

भुजकोटिशशिमान् शुक्लपरिलेखं सूत्रपरिलेखान् ।
 प्रतिदिवसं प्रतिघटिकं यो वेत्तीदुद यज्ञः सः ॥ १ ॥
 पराच्य परादिगभिमुखं शुक्लेतरपक्षयोलिखेत भूमौ ।
 अपवर्त्तष्टेनैकेन राशिना कोटिभुजकर्णात् ॥ २ ॥
 परिकल्पाकं बिन्दुं तस्माद्बाहुं यथादिशं कृत्वा ।
 बाहुग्रात्प्राच्यपरां कोटिं तिर्यकथं कर्णः ॥ ३ ॥

१. (घ) १. छेदभुजकोटिकर्णशशि (ग) भुजकोटिकर्णशशि for (भुजकोटिशशि)
 २. परिलेख for (परिलेख) (ग) 'परिलेख' लुप्त है ।
 ३. परिलेखान् (ग) परिलेखात् for (परिलेखान्)
 (ग) ४. वेत्तं for (वेत्ती) ५. हृदयज्ञः for (दुंदयज्ञः)
 (च) १. भुजकोटि कर्णशशिमान् for (भुजकोटिशशिमान्)
 २. परिलेख for (परिलेख) ३. परिलेखान् for (परिलेखान्)
 ४. वेत्तीदुदं for (वेत्तीदुद)
 (ङ) २. सित for (परिलेख) ३. लेखात् for (लेखान्)
 ४. वेत्ति for (वेत्ती) ५. स तन्त्रहृदयज्ञः for (दुंदयज्ञः सः)
 २. (घ) १. प्राच्य (ग) (च) (ङ) for (पराच्य)
 २. मुखं for (मुखं) ३. लिषेत (ग) लिखेद्भूमौ for (लिखेत भूमौ)
 ४. कर्णान् (ङ) (च) for (कर्णात्)
 (ग) ५. पदिगभि मुखं for (परादिगभिमुखं)
 ६. तरतर for (तर) ७. अपवर्त्तष्टेनैकेन (ङ) for (अपवर्त्तष्टेनैकेन)
 ८. वाशिना for (राशिना)
 (च) २. मुखं for (मुखं) ३. लिषेत् for (लिखेत)
 (ङ) ४. लिखेत् (लिखेत)
 ३. (घ) १. बाहुग्रात् (ग) (ङ) for (बाहुग्रात्)
 २. तिर्यक् स्थितं (ग) तिर्यक्स्थितं कर्णम् ॥ ३ ॥
 (ग) ३. बिन्दुं (ङ) for (बिन्दु) ४. यथादिशं (यथादिशं) ५. कोटि for (कोटि)
 (च) ६. परिकल्पाकं for (परिकल्पाकं) २. तिर्यकथं for (तिर्यकथं)
 (ङ) ६. परिकल्प्याकं for (परिकल्पाकं)
 ७. दत्त्वा for (कृत्वा) २. तिर्यक्स्थितं कर्णं for (तिर्यकथं कर्णः)

कर्णाग्रि^३ चन्द्रमसं^३ परिलेख्य^३ सितं^३ प्रवेश्यकर्णै^३न ।
 शशिबिंबे^३ शुक्लाग्रात्परिलेखसमेन^३ सूत्रेण ॥ ४ ॥
 कर्णागतस्थेनेन्दो^३ शुक्लं^३ परिलेख्यं^३ पश्चिमाभिमुखः^३ ।
 राशिषु^३ मेषतुलादिषु^३ संशोध्य^३ दिवाकरं^३ चन्द्रात् ॥ ५ ॥
 पूर्वाभिमुखः^३ कर्कटमकरादिषु^३ भवति^३ शुक्लसंस्थानम् ।
 एवं वा संस्थानं^३ परिलेख्येन्दुं^३ प्रसाध्य^३ दिशः ॥ ६ ॥
 बाहुज्यैर्दुदलगुणाकर्णविभक्ता^३ भुजोन्यदिक् चन्द्रे ।
 कर्णोभुजागतश्चन्द्रमध्यगः^३ पूर्वच्छेषम् ॥ ७ ॥
 प्राच्यपरे विपरीते^३ फलकेन्यत्सर्वमुक्तवत्कार्यम् ।
 शृङ्गेनेनतिपरिलेखाश्चत्वारः^३ शीतकिरणस्य ॥ ८ ॥

४. (घ) १. कर्णाग्रि for (कर्णाग्रै) २. परिलेख्य (ग) परिलिख्य for (परिलेख्य)
 (ग) ३. बिंबे सूत्रां for (बिंबे शुक्ला)
 (च) २. परिलेख्य for (परिलेख्य) ४. परिलेख for (परिलेख)
 (ङ) २. परिलिख्य for (परिलेख्य)
५. (घ) १. कर्णा गतिस्थे (ग) (ङ) for (कर्णागतस्थे) २. मेष for (मेष)
 (ग) ३. नैशे for (नैन्दो) ४. परिलिख्य (ङ) for (परिलेख्य)
 ५. मुखम् (ङ) for (मुखः) ६. दिवाकरं for (दिवाकरं)
 (च) १. कर्णागतस्थेनेन्दो for (कर्णागतस्थेनेन्दो)
 ४. शुक्लं परिलेख्य for (शुक्लं परिलेख्य)
 (ङ) ३. नैशे for (नैन्दो) ७. शुक्ले for (शुक्ल)
६. (ग) १. परिलेखेन्दुं for (परिलेख्येन्दुं)
 (च) २. कर्कटं for (कर्कट) १. परिलिख्येन्दुं for (परिलेख्येन्दु)
 (ङ) ३. मुखं for (मुखः) १. परिलिख्येन्दुं for (परिलेख्येन्दु)
७. (घ) १. पूर्ववच्छेषम् (ग) पूर्ववच्छेषम् for (पूर्ववच्छेषम्)
 (ग) २. भुजात्य दिक्चन्द्रे for (भुजोन्यदिक्चन्द्रे) ३. मध्यतः (ङ) for (मध्यगः)
 (ङ) २. भुजान्यदिक् for (भुजोन्यदिक्) १. पूर्ववच्छेषम् for (पूर्ववच्छेषम्)
 (च) १. पूर्ववच्छेषं for (पूर्ववच्छेषम्)
८. (ग) १. प्राच्यपरे for (प्राच्यपरे) २. विपरीते for (विपरीते)
 ३. मुक्तवच्छेषम् for (मुक्तवत्कार्यम्) ४. शीत for (शीत)
 (च) ५. फलकेन्य सर्वमुक्त for (फलकेन्यत्सर्वमुक्त)
 (ङ) ६. वच्छेषम् for (वत्कार्यम्)

गृह्योगेदुच्छाया गृहदयोस्तमयभगृहयुतीनाम् ।
 तत्स्वक्रान्तिज्याद्युत्तराणि भगृहयुतौ न पृथक् ॥ ९ ॥
 इति परिलेखाध्यायः शशांक शृंगोन्नतेर्भुजाद्येषु ।
 शशिः शृङ्गोन्नत्युत्तरमार्यादशकेन सप्तदशः ॥ १० ॥
 इति सप्तदशाध्यायः समाप्तः

९. (ग) १. ग्रहोदयास्त (च) (ङ) for (ग्रहदयोस्त)
 २. मुनिनां for (युतीनाम्) ३. तत्क्रान्तिज्याप्ता (घ) for (तत्क्रान्तिज्याद्यु)
 ४. प्रथक् for (पृथक्)

(च) ५. द्या for (ज्या)

- (ङ) २. ग्रह मुनीनां for (ग्रह युतीनां)
 ३. तत्क्रान्तिज्या for (तत्स्वक्रान्तिज्या)
 ५. प्रश्नोत्तराणि for (द्युत्तराणि)

१०. (घ) १. भुजोज्येषु (ग) भुजाद्येषु for (भुजाद्येषु)
 २. 'इति' से 'समाप्त' तक अंकित नहीं है ।

- (ग) ३. : लुप्त हैं ५. शृंगोन्नत्युत्तर for (शृङ्गोन्नत्युत्तर)
 ६. मार्यादशकेन for (मार्यादशकेन)
 २. इति ब्रह्मसिद्धान्ते सप्तदशोऽध्यायः for (इति सप्तदशाध्यायः समाप्तः)
 ४. राशि for (शशि)

(च) २. 'इति' से 'समाप्तः' तक लुप्त

- (ङ) २. इति श्रीब्राह्मस्फुटसिद्धान्ते शृङ्गोन्नत्युत्तराध्यायः सप्तदशः
 for
 (इति सप्तदशाध्यायः समाप्तः)

अथ कुट्टकाध्यायः

अष्टादशः

प्रायेण यतः प्रश्नाः कुदाकाराद्वतेन शक्यन्ते ।
 ज्ञातुं वक्षामि ततः कुदाकारं सह प्रश्नैः ॥ १ ॥
 कुदकर्णं धनाव्यक्त मध्यमाहरणं वर्ण्यता वितकैः ।
 आचार्यस्तत्रविदां ज्ञातैर्वर्गं प्रकृत्याच्च ॥ २ ॥
 अधिकाग्रभागहारा द्वनाग्रछेदभाजिता शेषम् ।
 यत्तत्परस्य हृतं लब्धमध्योधः पृथक् स्थाप्यम् ॥ ३ ॥
 शेषं तथेष्टगुणितं यथाग्रयोरन्तरेण संयुक्तम् ।
 शुध्यति गुणकः स्थाप्यो लब्धं चांत्यादुपांत्यगुणाः ॥ ४ ॥

१. (घ) १. २ कुदाकाराद्वते (ग) कुदाकाराद्वते for (कुदाकाराद्वते)
 ३. वक्षामि (ग) (च) (ङ) for (वक्षामि)
 (ग) ४. प्रश्ना for (प्रश्नाः) ५. कुदाकारं (ङ) for (कुदाकारं)
 (च) २. द्वतेन for (द्वतेन)
 (ङ) १. कुदाकाराद्वते for (कुदाकाराद्वते)
२. (घ) १. कुदकर्णं for (कुदकर्णं)
 (ग) १. कुदकर्णधना for (कुदकर्णधना)
 २. कर्णभावितकैः (ङ) for (वर्ण्यतावितकैः)
 ३. विदा for (विदां) ४. वर्गं for (वर्गं)
 (च) ५. च for (च)
 (ङ) १. कुदकर्णं for (कुदकर्णं) ६. हरणैक for (माहरण)
३. (घ) १. छेषम् (च) (ङ) for (शेषम्)
 २. यत्तत्परस्परहृतं (ग) यत्तत्परस्परहृतं (ङ) for (यत्तत्परस्यहृतं)
 ३. मध्योधः (ग) मध्योधः (ङ) for (मध्योधः)
 (ग) ४. भावहारा for (भागहारा) ५. प्रथक् for (पृथक्)
 (च) ३. मध्योधः for (मध्योधः)
 (ङ) ६. द्वनाग्रछेद for (द्वनाग्रछेद)
४. (ग) १. गुणः (ङ) for (गुणाः)
 (ङ) २. यथाग्रयो for (यथाग्रयो)

स्तोर्द्धात्ययुतो^२ग्रातो^३ हीनाग्रछेदभाजितः शेषम् ।
 अधिक्राग्रछेदाहतमधिकाग्रयुतं भवत्यग्रम् ॥ ५ ॥
 छेदवधस्य द्वियुगछेद^४ वधोयुगतं द्वयोरग्रम् ।
 बुधकारेणैवं^५ त्र्यादिग्रहयुगगतानग्रनम् ॥ ६ ॥
 यो जानाति युगादिं ग्रहयुगपातैः पृथक् पृथक् तिथितैः ।
 द्वित्रिचतुः प्रभृत्तिनां कुट्टाकारं स जानाति ॥ ७ ॥

५. (घ) १. स्तोर्द्धात्ययुतो (ग) स्तोर्द्धात्ययुतो for (स्तोर्द्धात्ययुतो)

(ग) २. ग्रातो for (ग्रातो) ३. हृत for (हृत)

(च) १. स्तोर्द्धाति for (स्तोर्द्धात्य)

(ङ) १. स्तोर्द्धात्ययुतो for (स्तोर्द्धात्ययुतो)

२. ग्रान्तो for (ग्रातो) ३. छेदहत for (छेदाहत)

६. (घ) १. द्वियुगं (ग) (च) (ङ) for (द्वियुग)

३. रग्रम् for (रग्रम्) २. युगगतं (ग) युगमतं for (युगतं)

४. कुधकारेणैवं (ग) कुट्टाकारेणैवं (ङ) for (बुधकारेणैवं)

(ग) ५. छोदवहो for (छेदवधो)

(च) २. युगगतं (ङ) for (युगतं) ४. कुधकारेणैवं for (बुधकारेणैवं)

७. (घ) १. प्रभृत्तिनां (ङ) (ग) प्रभृत्तिनां for (प्रभृत्तिनां)

(ग) (वि०—यह श्लोक इस प्रति में श्लोक संख्या १५ पर है)

२. युगादीग्रह for (युगादिग्रह) ३. युगजातैः for (युगपातैः)

४. प्रथक् २ for (पृथक् पृथक्) ५. कथितैः for (तिथितैः)

६. कुट्टाकारं for (कुट्टाकारं) ७. जाति for (जानाति)

(च) ३. युगः यातैः for (युगपातैः)

४. पृथक्प्रथक्तिथितैः for (पृथक् पृथक् तिथितैः)

१. प्रभृत्तिनां for (प्रभृत्तिनां)

२. युगादि for (युगादि) ३. ग्रहयुगयातैः for (ग्रहयुगपातैः)

(वि०—श्लोक संख्या १५ है)

भगणादिशेषमग्नं छेदहतं ख चर दिनजशेषहतम् ।
 अनयोरग्नं भगणादि दिनजशेषोद्धृतं द्यगुणः ॥ ८ ॥
 अथवा जिनजभगणादिशेषं येन गुणं मंडलादि शेषोनं ।
 शुध्यति विभाजितं स्वेन भागहारेण सद्यगुणः ॥ ९ ॥
 मंडल राश्यंशकला विकलाशेषादभिष्टतः कथितान ॥
 आनयति दिनगणं यः कुठाकारं स जानाति ॥ १० ॥

८. (घ) १. छेदहतं (ग) (च) (ङ) for (छेदहतं)
 २. खंच (यहां मूल में 'र' नहीं है) for (खचर)
 ३. हतम् (च) (ङ) for (हतम्)
 ४. क्वगणः (ग) द्यगुणः for (द्यगुणः)
 (ग) ५. च for (चर)
 ६. भगणादिघृतं for (भगणादिदिनजशेषोद्धृतं)
 (वि०—इसकी श्लोक संख्या ७ है) (ङ)
 (च) २. खच for (खचर) ४. द्यगुणः (ङ) for (द्यगुणः)
 (वि०—इसकी क्रमसंख्या ७ है)
 ९. (घ) १. गणः for (गुणः)
 (ग) २. यह श्लोक 'दिनज' से आरम्भ होता है, (ङ)
 ३. शेषकयोः (ङ) for (शेषोनं)
 दूसरी पंक्ति बिल्कुल भिन्न है—
 "सदृशच्छेदो घृतयोस्तद्धातमहर्गणं द्यमतः" ॥८॥
 (च) १. सद्यगुणः for (सद्यगुणः)
 (ङ) २. 'अथवा' लुप्त, दिनज for (जिनज)
 दूसरी पंक्ति निम्नांकित—
 सदृशच्छेदोद्धृतयोस्तद्धातमहर्गणाद्यमनः for (शुध्यति विभाजितं स्वेन
 भागहारेण सद्यगुणः)
 (वि०—इसकी क्रमसंख्या ८ है)
 १०. (घ) १. दभीष्टतः कथितान् for (दभिष्टतः कथितान)
 २. कुठाकारं for (कुठाकारं)
 (च) १. दभीष्टतः for (दभिष्टतः) २. कुठाकारं for (कुठाकारं)
 (ङ) श्लोक उपलब्ध नहीं ।

यो जानाति^२ युगगतं^१ कथितादयिमास^५ शेषकादिष्टात् ।

अवभाव^१ शेषतो वा तद्योगाद्वासकुदज्ञः^३ ॥ ११ ॥

एकेष्टदिवसघटिका^१ विनाडिका^२ मंडलादिशेषकयोः ।

सद्रशछेदो^३ धृतयोस्तघात्^३ महर्गणाद्यमतः ॥ १२ ॥

हतयोपरस्परं^१ यच्छेषं^५ गुणकारभागहारकयोः ।

तेन हतौ^२ निच्छेदौ^५ तावेव परस्परं^१ हतयोः ॥ १३ ॥

लब्धमध्येधः^३ स्थाप्यं^२ तथेष्ट^१ गुणकारसंगुणं^५ शेषम् ।

शुध्यति^१ तथैकहीनं^२ गुणकः^५ स्थाप्यः^२ पलं चात्यात् ॥ १४ ॥

११. (घ) १. अवभाव (ग) (च) (ङ) for (अवभाव)

(ग) (वि०—इसकी श्लोक संख्या २५ है)

२. यो युगगतं for (यो जानाति युगगतं)

(च) ३. कुदज्ञः for (कुदज्ञः)

(ङ) (वि०—श्लोक संख्या २५ है)

२. जानाति यो for (यो जानाति) ४. दधिमास for (दयिमास)

१२. (घ) १. सद्रश (च) for (सद्रश) २. हृतयो (च) for (धृतयो)

३. स्तघात् for (स्तघात्)

(ग) यह श्लोक इस प्रति में उपलब्ध नहीं है ।

(च) ३. तघात् for (तघात्)

(ङ) श्लोक अनुपलब्ध है ।

१३. (घ) १. हृतयोः (ग) (ङ) for (हतयोः)

२. हतौ (ग) (च) for (हतौ)

(ग) ३. हृतयोः (च) for (हतयोः)

(वि०—इसकी श्लोक संख्या ६ है) (ङ)

(ङ) ३. हृतयोः for (हतयोः) ४. यच्छेषं for (यच्छेषं)

५. निच्छेदौ for (निच्छेदौ)

१४. (घ) १. यथैक (च) (ङ) for (तथैक)

२. स्थाप्यपलं (ग) स्थाप्यफलं for (स्थाप्यः पलं)

(ग) ३. लब्धमध्येध for (लब्धमध्येधः) ४. शेषे for (शेषं)

५. चात्यात् for (चात्यात्)

(वि०—इसकी श्लोक संख्या १० है) (ङ)

(च) ५. चाप्तात् or चात्यात् for (चात्यात्)

(ङ) ३. लब्धमध्येधः for (लब्धमध्येधः)

अग्रांत्यमुपांत्येना स्वाद्धौ गुणितोत्प संयुतो भगणः ।
 छेदभागहारेणैवं स्थिरकटुकः शेषम् ॥ १५ ॥
 इष्टभगणादिशेषात् स्वकुटकगुणात् स्वाभागहार हृतात् ।
 शेषं द्युगणोद्धत निरपर्वत गुणभागहारं युतः ॥ १६ ॥

१५. (घ) १. अग्रांत (ग) (च) (ङ) for (अग्रांत्य)

३. भक्तः (ग) (च) for (भगणः)

४. निछेदभागहारे for (छेदभागहारे)

५. कुटकः (ङ) for (कटुकः)

७. गुणितोत्प (त्प) (च) for (गुणितोत्प्य)

(ग) २. स्वेधौ for (स्वाद्धौ)

६. मुपांत्येन (ङ) for (मुपांत्येना)

(वि०—इसकी श्लोक संख्या ११ है)

४. निछेद for (छेद)

५. कुटकः for (कटुकः)

(ङ) २. स्वेधौ for (स्वाद्धौ)

३. भक्तः for (भगणः)

४. निः शेष for (छेद)

१६. (घ) १. कुटक (ङ) for (कटुक)

२. गुणस्त्वभाग (ग) गुणान् स्वभाग for (गुणात्स्वाभाग)

३. हृतात् (ग) हृतान् for (हृतात्)

४. गत (ग) भगणोगत for (द्युगणोद्धत)

५. निरपर्वत (ग) (च) (ङ) for (निरपर्वत)

६. भागहारयुतः (ग) गुणभागहारयुता for (गुणभागहारयुतः)

(ग) (वि०—इसकी श्लोक संख्या १२ है)

(च) ७. दष्ट for (इष्ट) १. कुटक for (कटुक)

२. गुणस्त्वभाग for (गुणात्स्वाभाग)

३. हृतात् for (हृतात्) ४. गत for (हत)

६. गुणभागहारयुतः (ङ) for (गुणभागहारयुतः)

(ङ) २. गुणात्स्वभाग for (गुणात्स्वाभाग) ४. गत for (हत)

एवं समेषु विषमेष्वृणां धनं धनमृणां यदुक्तं तत् ।
 ऋणधनयोर्व्यस्तत्वं गुण्यप्रक्षेपयोः कार्यम् ॥ १७ ॥
 गुणकछेदः छेदो गुणको धनमृणधनं कार्यम् ।
 वर्गे पदं पदकृति रंताद्वैपरित माद्यं तत् ॥ १८ ॥
 अंशक शेषा व्यूनास्तप्त हतान्मूल मूनमष्टाभिः ।
 नवभिर्गुणं सरूपं कदा शतं बुधदिने सवितुः ॥ १९ ॥

१७. (घ) १. विषमेष्वृणां (ग) पृणधन for (विषमेष्वृणां)
 (ग) ४. व्यस्तत्वं for (व्यस्तत्वं) ५. गुण्यम् for (गुण्य)
 (वि०—इसकी श्लोक संख्या १३ है) (ङ)
 (च) १. विषमेष्वृणां for (विषमेष्वृणां) २. प्रक्षेपयो for (प्रक्षेपयोः)
 (ङ) १. विषमेष्वृणां for (विषमेष्वृणां)
१८. (घ) १. छेदः (ग) छेद (च) for (छेदः छेदो)
 २. वैपरीत for (वैपरित)
 (ग) ३. मृणमृणां for (मृणा) ४. वागपदं for (वर्गेपदं)
 ५. रंत्याद्विपरित for (रंताद्वैपरित)
 (वि०—इसकी श्लोक संख्या १४ है) (ङ)
 (ग) + तिथिमानदिनेष्विष्टा ये ऽर्काद्यास्ते पुनः कदा तेषु ।
 इष्टग्रहवारे यः कथयति कुट्टकज्ञः सः ॥ ८ ॥ +
 इसकी श्लोक संख्या १८ के स्थान में ८ लिखी गई प्रतीत होती है ।
 (च) 'श्लोक' लुप्त
 (ङ) (वि०—इसकी क्रमसंख्या १८ है)
 १. ग्रहवारेषु for (ग्रहवारे)
 (च) ४. वर्गे पदं for (वर्गेपदं) ६. पदकृति for (पदकृति)
 ५. रंताद्वैपरीत for (रंताद्वैपरितं)
 (ङ) १. गुणकछेदश्छेदो for (गुणकछेदः छेदो)
 ४. वर्गेः पदं पदं for (वर्गेपदं पद)
 ५. रंत्याद्विपरीत for (रंताद्वैपरित)
१९. (घ) १. हतान् for (हतान्)
 (ग) (वि०—इसकी श्लोक संख्या २७ है)
 (ङ) (वि०—इसकी श्लोक संख्या २७ है)
 २. शेषाव्यूनात् for (शेषाव्यूनाम्)
 १. सप्तहतात् for (तप्तहतान्)

अ्यूनाधिमासः शेषात् मूलध्व्यधिकं विभाजितं षड्भिः ।
 द्यूनं वर्जितं मधिकं नवभिर्नवति कदा भवति ॥ २० ॥
 अवमावशेषं वर्गोन्येकोदशति विभाजितोऽध्व्यधिकः ।
 अष्टगुणे दशभक्ते द्वियुते ष्टादशकदा भवति ॥ २१ ॥
 इष्टभगणादिशेषां शुगणस्तत्कुट्टकेन संयुक्तः
 तच्छेददिनंस्तावद्दिनवारो यावदिष्टस्य ॥ २२ ॥

२०. (घ) १. शेषान्मूलं (ग) for (शेषात् मूल) २. द्व्यधिकं (ग) (च) for (ध्व्यधिकं)
 ३. वर्जितं (ग) (च) for (वर्जित) ४. नवतिः (ग) नवभिः for (नवतिः)
 (ग) (वि०—इसकी श्लोक संख्या २० है)
 ५. अ्यूनाधिमास for (अ्यूनाधिमास) ६. द्यूनं २ for (द्यूनं)
 (च) १. शेषान्मूलं for (शेषात् मूल) २. द्व्यधिकं for (ध्व्यधिकं)
 ४. नवतिः for (नवति)
 (ङ) (वि०—इसकी श्लोक संख्या २० है)
 ५. अ्यूनाधिमास for (अ्यूनाधिमासः)
 १. शेषान्मूलं for (शेषात् मूल) २. द्व्यधिकं for (ध्व्यधिकं)
 ६. द्यूनं for (द्यूनं) ३. वर्जितं for (वर्जित)
 ४. नवतिः for (नवति)
 २१. (घ) १. द्व्यधिकः (ग) (च) (ङ) for (ध्व्यधिकः)
 १. दशभक्तो (ग) (च) for (दशभक्तो)
 ३. द्वियुतोऽष्टादश (ग) (च) for (द्वियुते)
 (ग) (वि०—इसकी श्लोक संख्या २१ है)
 ४. शेषे for (शेष) ५. व्येको for (न्येको)
 ६. गुणे for (गुणे)
 (ङ) ५. व्येको for (न्येको)
 (वि०—इसकी श्लोक संख्या २१ है)
 २२. (ग) १. कुट्टकेन for (कुट्टकेन) २. दिष्टः for (दिष्ट)
 ३. स्यात् for (स्य)
 (वि०—इसकी श्लोक संख्या १९ के स्थान में ९ है)
 (च) १. कुट्टकेन for (कुट्टकेन)
 (ङ) (वि०—श्लोक संख्या १९ है)
 ४. शेषाद् for (शेषा) ५. तच्छेद for (तच्छेद)
 २. ३. यावदिष्टः स्यात् for (यावदिष्टस्य)

भगणाद्यमिष्टशेषं कर्देदुदिवसे खेर्गुरु दिने वा ।

ज्ञदिने वायः कथयति कुदाकारं स जानाति ॥ २३ ॥

ज्ञदिने यदंशशेषं विकलाशेषं कदा न दिदु दिने ।

भानोरथवा शशिनो यः कथयति कुटकज्ञः सः ॥ २४ ॥

इष्टेषुमान दिवसे द्विमासान्मून रात्रिशेषे वा ।

भूयस्ते यः कथयति पृथग् पृथग वा कुदज्ञः ॥ २५ ॥

२३. (घ) १. कथयति (च) for (कथयति)

२. कुदाकारं (ग) कुटकारं for (कुदाकारं)

(ग) ३. ज्ञदिनेराशयः for (ज्ञदिनेवायः)

(वि०—इसकी श्लोकसंख्या १६ के स्थान में केवल ६ लिखी है)

(च) १. कुदाकारं for (कुदाकारं)

(ङ) (वि०—श्लोकसंख्या १६ है)

३. राशीन् for (वायः) २. कुटकारं for (कुदाकारं)

२४. (घ) १. तदिदु (ग) (च) (ङ) for (नदिदु)

२. कुटकज्ञः (ग) for (कुटकज्ञः)

(ग) (वि०—इसकी श्लोक संख्या १७ के स्थान में ७ है)

(च) २. कुदकज्ञः for (कुटकज्ञः)

(ङ) (वि०—क्रमसंख्या १७ है)

१. कुटकज्ञः for (कुटकज्ञः)

२५. (घ) १. मासन्मून for (मासान्मून)

२. पृथगपृथगवा (ग) प्रथक् पृथग् वा स for (पृथग् पृथग वा)

३. कुदज्ञः (ग) for (कुदज्ञः)

(ग) (वि०—इसकी श्लोक संख्या २६ है)

१. न्यून for (न्मून)

४. दिवसेष्वधिमास for (दिवसे द्विमास)

(च) १. मासन्मून for (मासान्मून) २. पृथगपृथगवा for (पृथग् पृथगवा)

(ङ) (वि०—इसकी क्रमसंख्या २६ है)

४. दिवसेष्वधि for (दिवसे द्वि) १. मासन्मून for (मासान्मून)

५. रात्रि शेषे for (रात्रिशेषे) २. पृथक् for (प्रथग्)

२. पृथग् वा for (पृथग वा) ३. स कुदज्ञः for (कुदज्ञः)

निच्छेद^४भागहारा^२द्राश्यादि कलाना^१हता^३ङ्क्तात् ।
 भगण^२कलाभिर्लब्धं^३ मंडलशेषं^१ दिनगणो^२स्मात् ॥ २६ ॥
 एवं राश्यंश^३ कलाशेषा^१भ्यहर्गणः^२ प्राग्वत् ।
 नष्टस्थानेष्विष्टानं^१ कान् कृत्वोक्त^२ वच्छेषम्^३ ॥ २७ ॥
 यो राश्यादीन्^१ द्रष्टृ^३ वा मध्यस्थेष्वस्य^२ कथयति द्युगुणम् ।
 ध्व्यधिग्रहयोगाद्^१ ग्रहांतरा^२द्वा स कुटज्ञः ॥ २८ ॥

२६. (घ) १. कलादिनाहताङ्क्तात् (ग) कलादिना हताङ्क्तात् for (कलानाहताङ्क्तात्)
- (ग) (वि०—इसकी श्लोक संख्या २१ है ।) २. (लब्धं भमंडल for (लब्धं मंडल ।
- (च) १. कलादिनाहताङ्क्तात् for (कलानाहताङ्क्तात्)
- (ङ) (वि०—इसकी क्रम संख्या २१ है
४. निच्छेद for (निच्छेद) १. कलादिना for (कलाना)
३. हताङ्क्तात् for (हताङ्क्तात्)
५. दिनगणोस्मात् for (दिनगणोस्मात्)
२७. (घ) १. हर्गणः for (हर्गणः) २. छेषम् for (छेषम्)
- (ग) (वि०—इसकी श्लोक संख्या २२ है ।) ३. कलाविकला (ङ) for (कला)
४. शेषादहर्गणः (ङ) for (शेषाभ्यहर्गणः)
- (च) २. वच्छेषं for (वच्छेषम्) १. हर्गणः for (हर्गणः)
- (ङ) (वि० इसकी क्रम संख्या २२ है)
५. नष्टस्थानेष्विष्टान् for (नष्टस्थानेष्विष्टानं)
६. तान् for (कान्) ७. कृत्वा भक्तवोक्त for (कृत्वोक्त)
२. वच्छेषम् for (वच्छेषम्)
२८. (घ) १. द्युगणम् (ग) (च) (ङ) for (द्युगुणम्)
२. द्रवादि for (ध्व्यधि) (ग) द्रवादिग्रहसंयोगात् for (ध्व्यधिग्रहयोगाद्)
३. गुहांतरात् (ग) ग्रहांतराद्वा for (ग्रहांतराद्वा)
४. कुटज्ञः (ग) for (कुटज्ञः)
- (ग) (वि०—इसकी श्लोक संख्या २० है परंतु लिखो हुई १० है ।)
५. द्रष्टृ वा (च) (ङ) for (द्रष्टृ वा)
- (च) २. द्रवादिग्रह for (ध्व्यधिग्रह) ४. कुटज्ञः for (कुटज्ञः)
- (ङ) (वि०—इसकी क्रम संख्या २० है)
२. द्रवादिग्रह संयोगात् for (ध्व्यधिग्रहयोगाद्)
४. कुटज्ञः for (कुटज्ञः)

येन गुणो^१ शेषयुते^२ छेदः शुध्यति^३ हृत^४ स्वगुणकेन ।
 तद्भुक्तं^५ शेषं फलमेव शेषाद् ग्रहद्युगणैः ॥ २९ ॥
 रादयंशकला विकला शेषात्कथितादभीष्टतोनष्टात् ।
 यः साधयद्युपरिमानं^६ समध्यमा^७ कुदकज्ञः स ॥ ३० ॥
 इति श्री कुट्टक प्रकरणम्

२९. (घ) १. गुण (ग) गुणः for (गुणो) २. युतछेद (ग) हृताछेदः for (युते छेदः)
 ३. गरौः (ग) गरौ for (गुरौः)

(ग) (वि०—इसकी श्लोक संख्या २४ है) ४. हृदः for (हृत)
 ५. न तदुक्तं for (तद्भुक्तं) ६. फलमेवं for (फलमेव)

(च) १. गुणों शेषयुतां for (गुणो शेषयुते)
 ४. हृतः for (हृत) ३. द्युगरौः for (द्युगुरौः)

(ङ) १. (वि०—इसकी क्रम संख्या २४ है)
 १. गुणः for (गुणो) २. युतश्छेदः for (युते छेदः)
 ४. हृतः for (हृत) ७. शेषाद्ग्रह for (शेषाद्ग्रह)
 ३. द्युगरौ for (द्युगुरौः)

३०. (घ) १. त्पुपरिमान् (ग) त्पुपरिधमान् for (द्युपरिमान्)
 ५. वि०—मूल में 'इति श्री' पद नहीं है ।
 २. कुदकज्ञः (ग) for (कुदकज्ञः स)

(ग) (वि—इसकी श्लोक संख्या २३ है)
 ३. विकलांशशेषात् for (विकलाशेषात्)
 ४. समध्यमान् for (समध्यमा)

(च) १. साधयत्पुपरिमान् for (साधयद्युपरिमान्)
 ४. समध्यमात् for (समध्यमा) ५. 'इति श्री' लुप्त
 ६. कुदक for (कुदक)

(ङ) (वि०—इसकी क्रमसंख्या २३ है)
 ७. नष्टान् for (नष्टात्) १. साधयत्पुपरितान् for (साधयद्युपरिमान्)
 ४. समध्यमान् for (समध्यमा)
 २. कुदकज्ञः for (कुदकज्ञः) ५. 'इति - से—राम्' तक सब लुप्त ।

अथ धनर्णं श्रुत्यानां संकलना

धनयोर्धनमृणयोर्धनर्णयोरंतरं समैक्यखं ।

वर्णैक्यमृणं धनशून्ययोः द्वनं शून्ययोः शून्यम् ॥ ३१ ॥

ऋणमधिकाद् विशोध्यं धनं धनादृणमृणादधिकमूनात् ।

व्यस्तं तदंतरं वा ऋणं धनं न मृण भवति ॥ ३२ ॥

३१. (घ) १. शून्यानां for (श्रुत्यानां)

२. समैक्यं (ग) for (समैक्य)

३. खर्णैक्य (ग) स्वर्णैक्यमृण for (वर्णैक्यमृणं)

४. द्वनं (ग) for (द्वनं)

(ग) (वि०—इसकी श्लोक संख्या ३० है)

५. 'अथ' से 'संकलना' तक लुप्त है ।

६. स्वं for (खं)

(च) ५. अथधनर्णं for (अथधनर्ण)

१. शून्यानां संकलनाः for (श्रुत्यानां संकलना)

७. धनर्णयो for (धनर्णयो)

२. समैक्यं for (समैक्य)

३. खवर्णैक्य for (वर्णैक्य)

४. द्वनं for (द्वनं)

(ङ) १. शून्यानां for (श्रुत्यानां)

४. "द्वनं" लुप्त

६. संकलनम् for (संकलना)

८. + मृण + २. समैक्यं for (समैक्य)

३. ऋणमैक्यं च for (वर्णैक्य)

१. धनमृण for (मृणं)

३२. (घ) १. ऊन (ग) (च) (ङ) for (ऋण)

२. खादृणं (ग) (च) for (वा ऋणं)

३. 'ण' को लिखना भूल गया

(ग) (वि०—इसकी श्लोक संख्या ३१ है)

४. धनं धनमृणं भवति for (धनं न मृणभवति)

(च) ३. नमृभति for (न मृणभवति)

(ङ) २. स्यादृणं for (वा ऋणं)

३. धनमृणं for (नमृण)

शून्यविहीनमृणमृणं धनं धनं भवति शून्यमाकाशम् ।
 शोध्यै यदा धनमृणादरणं धद्धातदश्रेय्यम् ॥ ३३ ॥
 प्रत्युत्पन्नः ऋणमृणधनयोर्धति धनमृणयोर्धनं वधोवधनं भवति ।
 शून्यण्ययोः स्वधनयोः खशून्ययोर्वा वधः शून्यम् ॥ ३४ ॥

३३. (घ) १. दृणं (ग) (च) (ङ) for (दणं)

२. धनाद्वा (ग) (ङ) for (धद्धा)

३. क्षेप्यम् (ग) तदा क्षेप्यम् for (तदश्रेय्यम्)

(वि०—इसकी क्रमसंख्या ३४ लिखी है)

(ग) ४. विहिन for विहीन ५. शोध्यं (च) (ङ) for (शोध्ये)

(वि०—इसकी संख्या ३२ है)

(च) २. धट्वा for (धद्धा) ३. तदश्रेय्यं for (तदश्रेय्यम्)

(वि०—यहां क्रमसंख्या ३४ अंकित है)

(ङ) ७. तदा for (तद) ३. क्षेप्यम् for (श्रेय्यम्)

३४. (घ) १. शून्यर्णयोः (ग) (ङ) for (शून्यण्योः)

२. वधः (ग) (च) (ङ) for (वध)

(वि०—इसका संख्याक्रम ३५ लिखा है ।)

(ग) (वि०—इसकी श्लोक संख्या ३३ है, परन्तु 'प्रत्युत्पन्न' यहां लुप्त है) (ङ)

ऋणमृणधनयोर्धतौ धनमृणयोर्धनवधो धनं भवति ।

शून्यर्णयोः खधनयोः खशून्ययोर्वा वधः शून्यम् ॥ ३३ ॥

३. धातो (ङ) for (धति) ४. खधनयोः for (स्वधनयोः)

(च) ३. धति for (धति) ५. धनं for (धनं)

१. शून्यर्णयोः for (शून्यण्योः)

५. (वि०—यहां क्रमसंख्या ३५ अंकित है)

(ङ) ७. 'प्रत्युत्पन्नः' लुप्त

धनभक्त^१ धनमृणहृतं^२ मृणं^३ धनं^४ भवति^५ खं^६ खभक्तम्^७ ।
 खंभक्तमृणो^८ धनधनमृणधनेन^९ हृतमृणमृणं^{१०} भवति^{११} ॥ ३५ ॥
 खोद्धृतमृणधनं^{१२} वा तच्छेदं^{१३} खमृणधनं^{१४} विभक्तं^{१५} वा ।
 धनमृणधनयोर्वर्गः^{१६} खं^{१७} खस्यपदं^{१८} कृतियत्तत्^{१९} ॥ ३६ ॥
 योगोन्तरं^{२०} युतहीनो^{२१} द्विहतः^{२२} संक्रमणमंतरविभक्तम्^{२३} ।
 वार्गान्तरमंतरं^{२४} युतहीनं^{२५} द्विहतं^{२६} विषमकर्म^{२७} ॥ ३७ ॥

३५. (घ) (वि०—इस श्लोक की दूसरी पंक्ति का आरंभिक 'खं' पहली पंक्ति का अंतिम शब्द है)

१. हृतमृणं (ग) (ङ) (च) for (हृतमृणं)

२. धनं (ग) (च) (ङ) for (धन) ३. मृणं (ग) (च) (ङ) for (मृण)

४. हृत (ग) (च) (ङ) for (हृत)

(वि०—इसका संख्याक्रम ३६ लिखा है)

(ग) ५. भक्तं खम् । यहां 'खं' पहली पंक्ति का अंतिम पद है ।

दूसरी पंक्ति 'भक्त' से आरम्भ होती है । इसकी क्रमसंख्या ३४ है । (ङ)

६. मृणो (ङ) for (भक्तमृणो) ७. 'वन' यह पद लुप्त है (ङ)

८. मृणधनं भवति for (मृणमृणं)

(च) १. यहां क्रमसंख्या '३६' अंकित है ।

३६. (घ) १. वाः for (वा)

(वि०—इसका संख्याक्रम ३७ लिखा है)

(ग) २. कृतियं कृत् for (कृतियत्तत्)

(वि०—इसकी श्लोक संख्या ३५ है)

(च) ३. (वि०—यहाँ क्रमसंख्या ३७ अंकित है)

(ङ) ४. मृणं for (मृणं) ५. तच्छेदं for (तच्छेदं)

६. ऋणधनयो for (धनमृणधनयो)

७. स्वं खं for (खं) ८. यत्तत् for (यत्तत्)

३७. (घ) १. हृतः (ग) (च) (ङ) for (हृतः)

२. वार्गान्तर (ग) (च) (ङ) for (वार्गान्तर)

३. हृतं (ग) (च) (ङ) for (हृतं) ४. कर्मः (ग) (च) for (कर्म)

(वि०—इसका संख्याक्रम ३८ लिखा है)

(ग) ५. युतहीनो for (युतहीनो) (वि०—इसकी श्लोक संख्या ३६ है)

(च) ६. (वि०—यहाँ क्रमसंख्या ३८ अंकित है)

(ङ) ७. + वा +

करा^१णलंबस्तत्कृति^२ रिष्ट^३हृतेष्टो^४न संयुतोऽल्पोभूः ।
 अधि^१को द्विह^२तो बाहु^३ संक्षेप्यावद्वधो^४ वर्गः ॥ ३८ ॥
 इष्टो^१द्धृत करणी^२ पदक्रतियुतिरिष्टगुणितांतरकृतिर्वा^३ गुण्यः^४ ।
 स्तिर्यगधो^१धो गुणकः^२ समसद्गुणः^३ सहितः^४ ॥ ३९ ॥
 सेष्टर्ण^१छेदगुणो^२ भाज्यछेदौ^३ पृथक् युतावसकृत् ।
 छेदकगत^१ हृतौ^२र्द्धौ^३ भाज्यो^४ वर्गः^५ समद्विवधः^६ ॥ ४० ॥

३८. (घ) १. करणी (ग) (ङ) for (कराणं)
 २. हृतो (ग) (च) for (हतो) ३. बाहु (ग) बाहुः (ङ) for बाहु
 (वि०—इसका संख्याक्रम ३९ है ।)
 (ग) ४. हृते (च) for (हृते) ५. संयुताल्पोभूः for (संयुतोऽल्पोभूः)
 ६. संक्षेप्या यद्वधो for (संक्षेप्यावद्वधो)
 (च) १. करणी for (कराणं) ७. (यहां क्रमसंख्या ४९ अंकित है)
 (ङ) ५. संयुताल्पोभूः for (संयुतोऽल्पोभूः) ६. संक्षेपो यद्वधो for (संक्षेप्यावद्वधो)
 ३९. (घ) १. करणी (ग) (च) (ङ) for (कराणी)
 २. 'गुण्य' यह पद दूसरी पंक्ति के आरम्भ में है (ग)
 (वि०—इसका संख्याक्रम ४० है)
 (ग) ३. पदयुतिकृति for (पदक्रतियुति) २. गुणास्ति for (गुण्यः)
 ४. गुणक (ङ) for (गुणकः) ५. समस्तद्गुण सहितः ॥ ३८ ॥ for
 (समसद्गुणः सहितः ॥ ३९ ॥)
 (च) २. वर्गुण्य for (वर्गुण्यः) ६. (यहां क्रमसंख्या ४० अंकित है)
 (ङ) ३. पदयुतिकृति for (पदक्रतियुति) २. 'गुण्यः' दूसरी पंक्ति का आरम्भिक पद ।
 ५. समस्तद्गुणः for (समसद्गुणः)
 ४०. (घ) हृतो (ग) (च) (ङ) for (हृतौ)
 २. समद्विवधः (ग) समिद्विवधः for (समद्विवधः)
 (वि०—इसका संख्याक्रम ४१ है)
 (ग) ३. गुणौ for (गुणो) ४. प्रथक् for (पृथक्) ५. वा भाज्यो (ङ) for (र्द्धौभाज्यो)
 (वि०—इसकी क्रमसंख्या ३९ है) (ङ)
 (च) ३. सेष्टर्णछेदगुणो for (सेष्टर्णछेदगुणो) ६. भाज्यछेदौ for (भाज्यछेदौ)
 ५. र्द्धौभाज्यो for (र्द्धौभाज्यो) २. समद्विवधः for (समद्विवधः)
 ७. (वि०—यहां क्रमसंख्या ४१ अंकित है)
 (ङ) ३. छेदगुणौ for (छेदगुणो) ७. युजावसकृत् for (युतावसकृत्)
 २. समद्विवधः for (समद्विवधः)

इष्टकरन्यूनाया रूपकृतेः पदयुतोतरूपाद्धे ।

प्रथमे रूपाण्यन्यहिना द्वितीयं करण्यसकृत् ॥ ४१ ॥

अन्यक्तवर्गधनवर्गवर्ग पंचगतषड्भूतादीनाम् ।

तुल्यानां संकलित व्यवकलिते पृथगतुल्यानाम् ॥ ४२ ॥

सदृश द्विवधो वर्गत्रयादिवधस्तद्गतोऽन्यरूपवधः ।

अन्योन्यवर्गघातो भावितकः पूर्ववच्छेषम् ॥ ४३ ॥

४१. (घ) १. करण्यूनाया (ग) (च) (ङ) for (करण्यूनाया)

२. प्रथमं (ग) (ङ) for (प्रथमे) ३. द्विना (ग) द्वितिय for (हिना)
(वि०—इसका संख्याक्रम ४२ है)

(ग) ४. रूपकृतेः (ङ) for (रूपकृतैः) ५. युतो for (युतो)

६. 'द्वितीयं' लुप्त है
(वि०—इसकी श्लोक संख्या ४० है)

(च) ३. रूपाण्यन्यहिना for (रूपाण्यन्यहिना)
(वि०—यहां क्रमसंख्या ४२ अंकित है)

(ङ) १. ण्यूनाया for (न्यूनाया) ३. ततो for (हिना)

४२. (घ) (वि०—इसका संख्याक्रम ४३ है ।)

(ग) १. धनवर्ग (ङ) for (धनवर्ग) २. यहां एक 'वर्ग' लुप्त है ।

३. गतः for (गत) ४. संकलिते for (सङ्कलित)

५. 'व्यवकलिते' लुप्त है

६. प्रथम for (पृथम)
(वि०—इसकी श्लोक संख्या ४१ है)

(च) ७. (वि०—यहां क्रमसंख्या ४३ अंकित है)

(ङ) (वि०—क्रमसंख्या ४१ है)

४३. (घ) (वि०—इसका संख्याक्रम ४४ है)

१. वर्ग (ग) (ङ) for (वर्ग)

(ग) २. द्विवधो for (द्विवधो) ३. न्यवधः for (अन्यरूपवधः)

४. सन्योन्य for (अन्योन्य)
(वि०—इसकी श्लोकसंख्या ४२ है)

(च) १. वर्ण्य for (वर्ग)

५. (वि०—यहां क्रमसंख्या ४४ अंकित है)

(ङ) ३. अन्यजातिवधः for (अन्यरूपवधः) ६. पूर्ववच्छेषम् for (पूर्ववच्छेषम्)

'इति धनवर्गादीनां सङ्कलित व्यवकलितादि'

मंडलशेषाद्युनान्मूलं व्येकं दशाधृतं द्वियुतम् ।
 मंडलशेषं व्येकं भानोर्जदिने कदा भवति ॥ ५० ॥
 अधिमास शेषपादा न्यूनाद्वर्गोधिमासशेषसमः ।
 अवमावशेषतो वा वमवशेषसमः कदा भवति ॥ ५१ ॥
 आद्याद्वर्गादिन्यान् व्यस्तान्प्रोह्याद्यमानमाद्यहतात् ।
 सद्रशा छेदान् सकृत् द्वौ व्यस्तौ उदकोबप्पू ॥ ५२ ॥

५०. (घ) (वि०—इसकी क्रमसंख्या ५१ है)

१. द्वचू (ग) द्युनामूलं for (द्युनामूलं)

२. हृतं (ग) हृतं for (धृतं) ३. व्येकं (ग) (ङ) for (व्येक)

(ग) . (वि०—इसकी श्लोक संख्या ४६ है)

(च) १. द्वचू नान् for (द्युनान्) २. हृतं for (धृतं)

४. (वि०—इसकी क्रमसंख्या ५१ अंकित है)

(ङ) १. द्वचू नान्मूलं for (द्युनामूलं) २. दशाहृतं for (दशाधृतं)

५१. (ग) (वि०—इसकी क्रमसंख्या ५२ है)

(ग) १. न्यूनाद्वर्गा for (न्यूनाद्वर्गो) २. यमः for (समः)

६. अमावशेषतो for (अवमावशेषतो) ४. 'व' लुप्त है (ङ)

(वि०—इसकी श्लोक संख्या ५० है)

(च) १. द्वर्गोधिमासशेषः for (द्वर्गोधिमासशेषः)

५. (वि०—क्रमसंख्या ५२ अंकित है)

(ङ) ६. पादात् for (पादा) १. न्यूनाद्वर्गो for (न्यूनाद्वर्गो)

१. हतात् (च) for (हृतात्) २. सदस (ग) सदशा for (सद्रशा)

३. नसकृत् (ग) for (नसकृत्)

४. कुहको (ग) (ङ) for (उदको) ५. बहुषु (ग) (ङ) for (बप्पू)

(वि०—इसकी श्लोक संख्या ५३ है)

(ग) (वि०—इसकी श्लोक संख्या ५१ है)

६. मद्य for (माद्य) ६. तत् for (तात्)

(च) २. सदस for (सद्रशा) ३. नसकृत् for (नसकृत्)

५. बप्पू for (बप्पू) (वि०—यहां श्लोक संख्या ५३ अंकित है)

(ङ) शीर्षक—इदानीमनेकवर्णसमीकरणमाह—

५. वर्णान् for (व्यस्तान्) २. सदश for (सद्रशा)

१. हृतम् for (हृतात्) ३. छेदावसकृद्वौ for (छेदान् सकृद्वौ)

गतभगणयुता द्युगुणा तद्वेषयुता तदैक्ययुताद्वा ।

तद्योगाद्वा द्युगुणो यः कथयति कुदकज्ञः सः ॥ ५३ ॥

गतभगणोना द्युना गणातछेषो ना तदैक्यहीनाद्वा ।

तद्विवराद्वा द्विगुणं यः कथयति कुदकज्ञः सः ॥ ५४ ॥

५३. (घ) १. गणात्त (ग) द्युगुणात् for (द्युगुणा)

२. छेष (ग) for (तद्वेष) २. तदैक्य (ग) for (तदैक्य)

४. गणं for (गुणो)

(वि०—इसकी क्रमसंख्या ५४ लिखी है)

५. गतभगणयुतात् for (गतभगणयुता)

६. संयुक्तात् (ङ) for (युताद्वा) ७. तद्योगाद्युगुणं for (तद्योगाद्वाद्युगुणो)

८. कुदकज्ञः (ङ) for (कुदकज्ञः)

(वि०—इसकी श्लोक संख्या ५२ है)

(च) १. द्युगुणा for (द्युगुणा) २. तद्वेषयुता for (तद्वेषयुता)

६. युक्ताद्वा for (युताद्वा) ७. तद्योगाद्वा for (तद्योगाद्वा)

४. द्युगुणं for (द्युगुणो) ८. कुदकज्ञ for (कुदकज्ञः)

१. (वि०—यहां श्लोक संख्या ६४ अंकित है)

(ङ) ५. भगणयुताद् for (भगणयुता) १. द्युगुणात् for (द्युगुणा)

२. तद्वेषयुतात् for (तद्वेषयुता)

४. द्युगुणं वा for (वा द्युगुणो)

५४. (घ) (वि०—इसकी क्रमसंख्या ५५ है)

१. द्युगणात्त (ग) द्युगणात्त for (द्युनागणा)

२. छेषानात्तदैक्य (ग) छेषोना for (छेषोना)

(ग) ३. नात् (ङ) नाद् for (ना) ४. तद्विवराद्युगुणं for (तद्विवराद्वा)

(वि०—इसकी श्लोकसंख्या ५३ है)

राश्याद्यैस्त छेषैश्चैवं भुक्ताविमास हीनदिनैः ।

तद्वेषैश्चयुगगतं य कथयति कुदकज्ञः सः ॥ ५४ ॥

(ङ) १. दिनहीनैः for (हीनदिनैः) २. तद्वेषैश्च for (तद्वेषैश्च)

(च) १. द्युगणा for (द्युनागणा) ५. तदैक्य for (तदैक्य)

६. कुदकज्ञ for (कुदकज्ञ) ७. (वि०—यहां क्रमसंख्या ५५ अंकित है)

(ङ) ३. द्युगणात् for (द्युनागणा) २. तद्वेषोनात् for (तद्वेषोना)

४. द्युगुणं वा for (वाद्विगुणं)

अंशक शेषेण युता स्त्रिप्ता शेषात्र तदंतरादथवा ।
 भानोर्जदिने द्युगुणं यः कथयति कुट्टकज्ञः सः ॥ ५५ ॥
 अंशक शेष त्रियुतं लिप्ता शेषं कदा र्वेर्जदिने षट् ।
 सप्ताष्टोन वा कुर्वन्नावत्सराद्गणकः ॥ ५६ ॥
 अंशसम मंशके कलासमं वा कला कदा शेषम् ।
 दिवसकरस्येष्ट दिने कुर्वन्नावत्सराद्गणकः ॥ ५७ ॥

५५. (घ) (वि०—इसकी क्रमसंख्या ५६ है)

१. लिप्ता (ग) (च) for (स्त्रिप्ता) ३. द्युगुणं (च) (ङ) for (द्युगुणं)

२. शेषात्तदंतरा (ग) (च) for (शेषात्रतदंतरा)

४. कुट्टकज्ञ (ग) कुट्टकज्ञः for (कुट्टकज्ञः)

(ग) ५. हता for (युता) (वि०—इसकी श्लोक संख्या ५५ है)

(च) ४. कुट्टकज्ञः for (कुट्टकज्ञः) (वि०—इसकी क्रमसंख्या ५६ अंकित है)

(ङ) ५. युतात् for (युता) लिप्ता for (स्त्रिप्ता)

२. शेषात् for (शेषात्र)

५६. (घ) (वि०—इसकी क्रमसंख्या ५७ है) १. नं वा (ग) नावां for (नवा)

(ग) २. शेषं (ङ) for (शेष)

३. 'षट्' दूसरी पंक्ति का प्रथम पद है (ङ)

४. सप्ताष्टौ for (सप्ताष्टो)

(वि०—इसकी श्लोकसंख्या ५६ है)

(च) १. सप्ताष्टोनं for (सप्ताष्टोन)

५. (वि०—इसकी क्रमसंख्या ५७ अंकित है)

(ङ) १. नव वा for (न वा)

४. सप्ताष्टौ for (सप्ताष्टो)

५७. (घ) (वि०—इसकी क्रमसंख्या ५८ है)

१. मंशाशकज्ञा for (मंशके) २. कदा (ग) for (कला)

६. कला (ग) for (कदा) ४. दिवसकरस्येष्ट for (दिवसकरस्येष्ट)

५. त्थराद्गणकः for (त्सराद्गणकः)

(ग) ६. अंशयुगमंशशेषं for (अंशसममंशके) ७. कलासमंश for (कलासमं)

(वि०—इसकी क्रमसंख्या ५८ है, संख्या ५७ अंकित करना भूल गया)

(च) १. मंशशे for (मंशके) २. ३. कदा कलाशेषं for (कलाकदाशेषम्)

४. दिवसकरस्येष्ट दिने for (दिवसकरस्येष्ट दिने)

५. त्थराद्गणकः for (त्सराद्गणकः)

(ङ) १. मंशशेषं for (मंशके) ३. 'कदा' लुप्त

अवभावशेषमवमैरधिमासकशेषमधिकमासैर्वा ।
 इष्टयुतो^१नं तुल्यं कुर्वन्नावत्सरगणकः ॥ ५८ ॥
 निच्छेद^३ भागहारो भानो^१ सप्ततिगुणो^२शशेषोनः ।
 शुध्यत्ययुत विभक्तः कुर्वन्नावत्सराद्गणकः ॥ ५९ ॥
 भावितकरूप गुणना साव्यक्तवधेष्टभाजिता^१ष्वासौ ।
 अल्पाधिको^२धिको^३लपेक्षेष्पौ भावितहूतौ^४ व्यस्तौ ॥ ६० ॥

५८ (घ) (वि०—इसकी क्रमसंख्या ५९ है)

१. सराद्गणकः for (सरगणकः)

(च) १. सद्गणकः for (सरगणकः)

२. (वि०—यहां क्रमसंख्या ५९ अंकित है) ३. वाः for (वाँ)

(ङ) ३. मधिमासैः for (मधिकमासैर्वा) १. सराद्गणकः for (सरगणकः)

५९. (घ) (वि०—इसकी क्रमसंख्या ६० है)

१. भागहारो (ङ) (भागहारो) २. गुणोऽंश for (गुणोऽंश)

(ग) ३. निच्छेद (ङ) for (निच्छेद) ४. भानोः (च) (ङ) for (भानोः)
 (वि०—क्रमसंख्या ५९ है)

(च) २. गुणोऽंशशेषोनः for (गुणोऽंशशेषो नः)
 (वि०—क्रमसंख्या ६० अंकित है)

६० (घ) (वि०—इस श्लोक की क्रमसंख्या ६१ है)

१. भाजितेष्ट्याप्तौ (ग) भाजितेष्ट्याप्त्योः (ङ) for (भाजिताष्वासौ)

२. अल्पेऽधिकोऽधिको (ग) अल्पेऽधिकल्पः for (अल्पाधिकोधिकोल्पे)

३. थौ (ग) क्षेप्यो for (क्षेप्यौ) ४. हूतौ (च) (ङ) for (हूतौ)

(ग) ५. व्यस्तम् (ङ) for (व्यस्तौ)

(च) १ भाजिष्ट्याप्तौ for (भाजिताष्वासौ)

६. (वि०—यहां क्रमसंख्या ६१ अंकित है)

(ङ) शीर्षक—+अथ भावितबीजम् +

२. अल्पेऽधिकोऽधिकेऽल्पः for (अल्पाधिकोधिकोल्पे)

३. क्षेप्या for (क्षेप्यौ)

भानोराश्य शवधो^२ त्रिचतुर्गुणितान्विशोध्यराश्यंशात्^३ ।

नवति^४ द्रष्ट्वा सूर्यं^५ कुर्वन्नावत्सरादगणकः ॥ ६१ ॥

भावितके तद्यातो विनष्ट वर्णेन तत्प्रमाणानि ।

ऋत्वेष्टानि तदाहृत वर्णैक्यं^४ भवति रूपाणि ॥ ६२ ॥

वर्णप्रमाणभावितघातो भवतीष्टवर्णसंख्यैवम् ।

सिध्यति विनापि भावितसमकरणात् किंकृतं तदतः ॥ ६३ ॥

मूलद्विधेष्टवर्णागुणगुणादियुतविहीनाच्च ।

आध्यवधो गुणक गुणः संहतपवातेन पमत्यम् ॥ ६४ ॥

६१. (घ) (वि० इस श्लोक की क्रमसंख्या ६१ है) १. नवति (ग) नति for (नवति)
 (ग) २. वधात्रि (ङ) for (वधात्रि) ३. राश्यंशान् for (राश्यंशात्)
 (च) १. नवति for (नवति) ४. द्रष्ट्वा (ङ) for (द्रष्ट्वा)
 ५. (वि०—यहाँ क्रमसंख्या ६२ अंकित है) (ङ) १. नवति for (नवति)
६२. (घ) (वि०—इसकी श्लोकसंख्या ६२ है) १. विनष्टे (च) for (विनष्ट)
 २. ऋत्वेष्टानि (ग) (च) (ङ) for (ऋत्वेष्टानि)
 (ग) ३. भाविक यद्यातो for (भावितके तद्यातो)
 (च) ५. (वि०—इसकी क्रमसंख्या ६३ अंकित है)
 (ङ) ६. यद्घातो for (तद्यातो)
६३. (घ) (वि०—इसकी क्रमसंख्या ६३ है)
 (ग) १. भवतिष्ट for (भवतीष्ट) २. संख्यैक्यम् for (संख्यैवम्) ३. काम for (सम)
 (च) ४. घातो for (घातो) ५. (वि० इसकी क्रमसंख्या ६४ अंकित है)
६४. (घ) (वि०—इस श्लोक की क्रम संख्या ६४ है)
 १. मूलं (ग) for (मूल) २. वर्गाद्गुण (ग) वर्गात् गुणक for (वर्गागुण)
 ३. आद्य (ग) (च) (ङ) for (आध्यवधो)
 ४. संहतपवातेन (ग) संहत्य घातेन for (संहतपवातेन)
 ५. पमत्यम् (ग) मन्त्यम् for (पमत्यम्)
 (ग) ३. द्विधेष्ट for (द्विधेष्ट) ७. गुणादियुत for (गुणादियुत)
 ८. विहीनाच्च for (विहीनाच्च) ९. गुण for (गुणः)
 (च) २. वर्गाद्गुण for (वर्गागुण) ४. संहतपवातेन for (संहतपवातेन)
 ५. पमत्यम् for (पमत्यम्) १०. (वि०—इसकी क्रम संख्या ६५ अंकित है)
 (ङ) श्री—†अथ वर्ग प्रकृतिः †
 २. वर्गाद् गुणक for (वर्गागुण) ७. गुणादिष्ट for (गुणादि)
 ४. संहान्यघातेन for (संहतपवातेन) ५. कृतमन्त्यम् for (पमत्यम्)

वज्ञावाधैक्यं प्रथमं प्रक्षेपः क्षेप्य शोध्यतुल्यवधः ।

प्रक्षेपशोधकहूते मूले प्रक्षेपके रूपे ॥ ६५ ॥

रूपप्रक्षेपपदे पृथगीष्टक्षेप्यशोध्यमूलाभ्याम् ।

कृत्वाद्योत्पाद्यपदे प्रक्षेपे शोधने वेष्टं चतुरधिके ॥ ६६ ॥

इत्यपदकृतिस्त्र्यूना दलितांत्य पदगुणात्पदम् ।

अंत्यपदकृतिव्येका द्विहताद्यपदा हताद्यपदम् ॥ ६७ ॥

६५. (घ) (वि०—इस श्लोक की क्रम संख्या ६६ है)

१. वज्ञवधैक्यं (ग) वज्रमधैक्यं for (वज्ञावाधैक्यं)

२. हूते (ग) तुहूते for (हूते)

(ग) ३. 'शोध्य' पद लुप्त है ।

(च) १. वज्ञवाधैक्यं for (वज्ञावाधैक्यं)

२. हूते for (हूते)

४. (वि०—यहाँ क्रमसंख्या ६६ अंकित है ।)

(ङ) १. वज्रवधैक्यं for (वज्ञावाधैक्यं)

३. दोषवधतुल्यः for (क्षेप्यशोध्यतुल्यवधः) २. हूते for (हूते)

६६. (घ) (वि०—इस श्लोक की क्रम संख्या ६७ है)

१. पृथगीष्ट (ग) (च) (ङ) for (पृथगीष्ट)

२. ऽधोत्पाद्य (ग) कृत्वाद्योत्पाद्य पदे for (कृत्वाद्योत्पाद्यपदे)

(ग) ३. रूपं for (रूप) ४. 'क्षेप्य' पद लुप्त है ।

५. वेष्टे (यहाँ श्लोक समाप्त है), 'चतुरधिके' ६७ वें श्लोक का आरंभ है ।

(च) ४. रूपप्रक्षेपपदे for (रूपप्रक्षेपपदे) २. ऽधोत्पाद्य for (धोत्पाद्य)

५. वेष्टे for (वेष्ट) ६. रधिके for (रधिके)

(ङ) २. कृत्वाऽऽन्त्याद्यपदे for (कृत्वाद्योत्पाद्यपदे)

७. +वे+ ५. वेष्टे for (वेष्ट) ६. "चतुरधिके" लुप्त

६७. (घ) (वि०—इसकी श्लोक संख्या ६७ है)

१. गुणांत्यपदं (ग) for (गुणात्पदम्)

२. व्येका (च) (ङ) for (व्येका) ३. हुता (ग) (च) (ङ) for (हुता)

(ग) ४. चतुरधिकेत्य for (इत्य) ५. पदं for (पद)

६. पादा for (पदा)

(च) ६. स्त्र्यूना for (स्त्र्यूना)

१. गुणांत्यपदं for (गुणात्पदं)

७. व्येका for (व्येका)

८. (वि०—क्रमसंख्या ६८ अंकित है)

(ङ) ४. चतुरधिकेऽन्त्य for (इत्य) १. गुणाऽन्त्यपदम् for (गुणात्पदम्)

चतुर्नैत्यपद कृताश्रकयुतेवधदलं प्रथम्वेकम् ।
 व्येकाध्यहतमंत्यं पदवधगुण मन्यदाद्यहदम् ॥ ६८ ॥
 वग गुणकः क्षेपः केनचिदुद्धृत युतो न को दलितः ।
 प्रथमोत्ये मूलमन्यो गुणरपदोद्धृत प्रथमम् ॥ ६९ ॥
 गुणके वर्गच्छिन्ने छेदपदे यो धृतपदं प्रथमवर्गः ।
 छेत्रे क्षेपे तन्मूले छेदपद गुणिते ॥ ७० ॥

६८. (घ) (वि०—इसकी श्लोक संख्या ६९ है) १. श्रैक for (श्रैक)
 २. पृथग् (ग) for (प्रथग्) (च) ३. द्याह (ग) (ङ) for (ध्यह)
 (ग) ४. चतुर्नैत्यपदकृतित्येकयुते for (चतुर्नैत्यपदकृता श्रैकयुते)
 ५. मन्यदाद्यपदम् for (मन्यदाद्यपदम्)
 (च) १. श्रैकयुते for (श्रैकयुते) ३. द्याहत for (ध्यहत)
 (ङ) ७. कृती for (कृता) १. श्रैकयुते for (श्रैकयुते)
 २. पृथग्व्येकम् for (प्रथम्वेकम्) ५. माद्यमान्य for (मन्यदाद्य)
 ६९. (घ) (वि०—क्रम संख्या ७० है) १. गुणकार (ग) (ङ) for (गुणर)
 २. पदोद्धृतः प्रथमम् (ग) धृतप्रथमः for (पदोद्धृत प्रथमम्)
 (ग) ३. वर्गण for (वर्ग) ४. गुणके (च) (ङ) for (गुणकः)
 ५. दुद्धृतो नितोदलितः for (दुद्धृत युतो नको दलितः)
 ६. प्रथमोत्ये (ङ) for (प्रथमोत्ये)
 (च) २. पदोद्धृतः for (पदोद्धृत) ७. (वि०—क्रम संख्या ७० अंकित है)
 (ङ) ७. युतो नितोदलितः for (युतो नको दलितः)
 २. पदोद्धृतः प्रथमः for (पदोद्धृत प्रथमम्)
 ७०. (घ) (वि०—इसकी क्रमसंख्या ७१ है)
 १. धृतं for (धृतपदं) २. प्रथमं for (प्रथम)
 ३. 'वर्ग' (यह शब्द दूसरी पंक्ति का आरंभिक पद है) ४. छिन्ने for (क्षेत्रे)
 (च) ६. वर्गच्छिन्ने for (वर्गच्छिन्ने) १. धृतपदं for (धृतपदं)
 ३. वर्गं for (वर्गः) ४. क्षेत्रे for (क्षेत्रे)
 ७. (वि०—यहाँ क्रम संख्या ७१ अंकित है)
 (ङ) 'वर्गच्छिन्ने' गुणके प्रथमं तन्मूलभाजितं भवति ।
 वर्गच्छिन्ने क्षेपे तत्पदगुणिते तदा मूले ॥ ७० ॥
 for
 गुणके वर्गच्छिन्ने छेदपदे यो धृतपदं प्रथमवर्गः ।
 क्षेत्रे क्षेपे तन्मूले छेद पद गुणिते ॥ ७० ॥

शशिलिप्ता शेषकृति^१द्विनवति^२ गुणिता अशिति^३ गुणितं^३ वा ।
 सैकांश दिने वर्गं^४ कुर्वन्नावत्सराद् गणकः ॥ ७१ ॥
 इष्टभगणादि शेषं^५ द्विनवत्पूतं^५ त्र्यशिति संगुणितम् ।
 ह्येण युतेन^६ वर्गं^६ कुर्वन्नावत्सराद् गणकः ॥ ७२ ॥
 भगणादिशेषवर्गं^७ चतुर्गुणं^७ पञ्चषष्टिसंयुक्तम् ।
 षष्ट्यूनं^८ वा वर्गं^८ कुर्वन्नावत्सराद् गणकः ॥ ७३ ॥

७१. (घ) १. कृतिः (ग) कृति for (कृति) (वि०—इसकी क्रम संख्या ७२ है)
 २. अशीति (ग) त्र्यशीति for (अशिति) ३. गुणितां for (गुणितं)
 ४. कुर्वन्नावत्सराद्गणकः (ग) for (कुर्वन्नावत्सराद्गणकः)
 (ग) ५. द्विनवगुणितं for (द्विनवतिगुणिता) ६. सैकं for (सैक)
 ७. वर्गे for (वर्ग)
 वि०—इसके आगे “गुणितं वा । सैकांश दिने वर्गे कुर्वन्ना० ॥ ७५ ॥”
 लिखा है ।
 (च) १. कृतिः for (कृति) ५. द्विनवति गुणितां for (द्विनवतिगुणिता)
 २. अशीति for (अशिति) ३. गुणितां वा for (गुणितं वा)
 ४. कुर्वन्नावत्सराद्गणकः for (कुर्वन्नावत्सराद्गणकः)
 ८. (वि०—यहाँ क्रमसंख्या ७२ अंकित है)
 (ङ) वि यह श्लोक इस प्रति में उपलब्ध नहीं है ।
७२. (घ) (वि०—इसकी क्रमसंख्या ७३ है)
 १. त्र्यशीति (ग) त्र्यशीति for (त्र्यशिति)
 २. युतं (ग) (ङ) for (युतेन)
 (ग) ३. वर्गं for (वर्ग) (वि०—इसकी श्लोकसंख्या ७७ है)
 (च) १. त्र्यशीति for (त्र्यशिति) २. युतं for युतेन
 ४. (वि०—क्रम संख्या ७३ अंकित है)
 (ङ) १. त्र्यशीति for (त्र्यशिति)
७३. (घ) (वि०—इसकी क्रम संख्या ७४ है)
 यह श्लोक १६०२ में बनारस से मुद्रित प्रति में ७८ संख्या पर है
 (ग) (वि०—यह श्लोक ‘ग’ में उपलब्ध नहीं है)
 (च) (वि०—क्रमसंख्या ७४ अंकित है)
 (ङ) (वि०—इसकी क्रमसंख्या ७८ अंकित है)

भगणादिशेष वर्गं त्रिभिर्गुणं संयुतं शतैर्नवभिः ।

वर्गोष्टशतोत्तं वा कुर्वन्नावत्सराद् गणकः ॥ ७४ ॥

अधिमासशेषवर्गं त्रयोदशगुणं त्रिभिर्युक्तम् ।

त्रिघनोत्तं वा वर्गं कुर्वन्नावत्सराद् गणकः ॥ ७५ ॥

अवमावशेषवर्गं द्वादशगुणितं शतेन संयुक्तम् ।

त्रिभिरूत्तं वा वर्गं कुर्वन्नावत्सराद् गणकः ॥ ७६ ॥

७४. (घ) (वि०—इसकी क्रमसंख्या ७५ है)

(ग) १. शतैर्नवभिः for (शतैर्नवभिः)

(वि०—इसकी क्रमसंख्या ७८ है)

(च) २. (वि०—क्रमसंख्या ७५ अंकित है)

(ङ) ३. कृतिमष्ट for (वर्गोष्ट)

७५. (घ) (वि०—इसकी क्रमसंख्या ७६ है)

१. त्रयोदश (ग) for (त्रयोदश) २. कुर्वन्नावत् (ग) (ङ) for (कुर्वन्नावत्)

(ग) ३. वर्ग for (वर्ग) ४. त्रिभिः शतैर्युक्तम् (ङ) for (त्रिभिर्युक्तम्)

५. वर्ग for (वर्ग)

(वि०—इसकी क्रमसंख्या ७९ है)

(च) १. त्रयोदश (ङ) for (त्रयोदश)

६. (वि०—यहां क्रमसंख्या ७६ अंकित है)

७६. (घ) (वि०—इसकी क्रमसंख्या ७७ है)

(च) (वि०—इसकी क्रमसंख्या ७७ है)

(ङ) (वि०—इसकी क्रमसंख्या ८२ है)

(ग) (वि०—इसकी क्रमसंख्या ८० है)

७६. संख्या पर अंकित निम्नांकित अतिरिक्त श्लोक है—

सूर्यादि विलिप्ताशेषं पंचभिरूनाद्गतं तथा दशभिः ।

वर्गो बृहस्पतिं दिने कुर्वन्नावत्सराद् गणकः ॥ ७६ ॥

(वि०—यह श्लोक इस प्रति में क्रमसंख्या ७६ पर है)

१. सूर्य for (सूर्यादि) २. रूनाहतं for (रूनाद्गतं)

३. वर्ग for (वर्गो)

गुणकयुतिरष्टगुणिता गुणिकांतरवर्गभाजिता राशिः ।
 गुणकौ त्रिगुणौ व्यस्ताधिकौ हृतावन्तरेण पदे ॥ ७७ ॥
 इन्दुविलिप्ताशेषं सप्तदशगुणं च यो दशगुणं च ।
 पृथगेयुतं वर्गं कुर्वन्नावत्सराद् गुणकः ॥ ७८ ॥
 वर्गोनकृतियुतो नानगास्तत्संयोंतरार्द्धकृतिभक्तः ।
 तद्गुणकौ युतिवियुतौ वर्गो घाते च रूपयुते ॥ ७९ ॥

७७ (घ) (वि०—इसकी क्रमसंख्या ७८ है)

१. गुणकांतर (ग) (ङ) (च) for (गुणिकांतर)

३. हृतावन्तरेण (ग) हृतावन्तरेण (च) (हृतावन्तरेण)

(ग्र) (वि०—यह श्लोकसंख्या इस प्रति में ७० पर, तथा बनारस में मुद्रित प्रति में ७१ पर अंकित है)

(च) (वि०—यहां क्रमसंख्या ७८ अंकित है)

(ङ) (वि०—इसकी क्रमसंख्या ७१ है)

७८. (घ) (वि०—इसकी क्रमसंख्या ७९ है)

१. त्रयोदश for (चयोदश) (ग) 'च'से 'च' तक लुप्त

(ग) ३. गुणितं वा for (गुणं च) ३. पृथगेक (ङ) for (पृथगे)

(वि०—इसकी क्रमसंख्या ८१ है)

(च) १. त्रयोदश (ङ) for (चयोदश)

४. (वि०—क्रमसंख्या ७९ अंकित है)

(ङ) ५. चापि for (च)

७९. (घ) (वि०—इसकी क्रमसंख्या ८० है)

१. नगास्तत्सांयोंतरार्द्धं (ग) नस्तत् संयोंगांतरार्द्धं for (नानगास्तत्संयोंतरार्द्धं)

(ग) २. न्यकृति for (नकृति) ३. कृतिभक्तः for (कृतिभक्तः)

४. तद्गुणितौ (ङ) for (तद्गुणकौ)

(च) २. वर्गोन्यकृति for (वर्गोनकृति)

१. नगास्तत्संयोंतरार्द्धं for (नानगास्तत्संयोंतरार्द्धं)

४. तद्गुणको for (तद्गुणकौ)

५. (वि०—यहां क्रमसंख्या ८० है)

(ङ) (वि०—इसकी क्रमसंख्या ७२ है)

२. वर्गोन्यकृति for (वर्गोनकृति) १. नस्तत् for (नानगास्तत्)

५. वर्गो for (वर्गो) ६. संयोंगान्तरार्द्धं for (संयोंतरार्द्धं)

यैरूना यैश्चयुतो रूपैर्वगस्तदैक्यमिष्टहृतम् ।
 इष्टोनं तद्लकृतिरूनाभ्यधिका भवन्ति राशिः ॥ ८० ॥
 याम्यां कृतिरधिकोनस्तदंतरं हृतयुतो न मिष्टेन ।
 तद्लकृतिरधिके न्यूनाभ्यधि भवति राशिः ॥ ८१ ॥
 जदिनेर्ज्ज कलाशेषं गुरु दिनविकलावशेष युक्तोनम् ।
 वर्गोविधं च सैकं कुर्वन्नावत्सराद् गणकः ॥ ८२ ॥

८०. (घ) (वि०—इसकी क्रमसंख्या ८१ है)
 १. वर्गं (ग) (ङ) for (वर्ग) २. हृतं (ग) (ङ) for (हृतम्)
 ३. भवति (ग) (च) (ङ) for (भवन्ति)
 ४. राशिम् (च) for (राशिः)
 (ग) (वि०—इसकी क्रमसंख्या ७२ है)
 (च) १. वर्गस्तदैक्य for (वर्गस्तदैक्य) ५. (वि०—इसकी क्रमसंख्या ८१ अंकित है)
 (ङ) (वि०—इसकी क्रमसंख्या ७३ है) १. वर्गस् for (वर्गस्)
 ८१. (घ) १. रधिकेन for (रधिके) (वि०—इसकी क्रमसंख्या ८२ है)
 २. राशिः (ग) (च) (ग) for (राशि)
 (ग) १. रधिकोना धिकयोरधिकोनयो राशिः for (रधिके न्यूनाभ्यधि भवति राशिः)
 ३. हृत (ङ) (च) for (हृत) ४. मीष्टेन for (मिष्टेन)
 ५. ६. 'न्यूनाभ्यधि' 'भवति' पद लुप्त हैं ।
 (च) १. रधिकेन for (रधिके) ५. न्यूनाभ्यधिका for (न्यूनाभ्यधि)
 ७. (वि०—क्रमसंख्या ८२ अंकित है)
 (ङ) १. रधिकोना for (रधिके)
 ५. धिकयोरधिको for (न्यूनाभ्यधि) ६. नयो for (भवति)
 ८२. (घ) (वि० इसकी क्रमसंख्या ८३ है)
 (ग) (वि०—इसकी क्रमसंख्या ८२ है)
 १. जदिनेर्ज्ज for (जदिनेर्ज्ज) २. दिने for (दिन)
 ३. वर्गं वन for (वर्गोविधं)
 (च) १. जदिनेर्ज्ज for (जदिनेर्ज्ज) २. दिनविकला for (दिनविकला)
 ३. वर्गोविधं for (वर्गोविधं) ४. (वि०—क्रमसंख्या ८३ अंकित है)
 (ङ) (वि०—इसकी क्रमसंख्या ८३ है)
 ३. वर्गं विधं च for (वर्गो विधं च)

विकलाशेषं^३ सहितं^३ त्रिवत्याऽ^३ सप्तषष्टिहीनं^३ च
 भानोर्ज्ञदिने^३ वर्गं^३ कुर्वन्नावत्सराद्^३ गणकः ॥ ८३ ॥
 जदिनेऽर्कं^३ कलाशेषं^३ वर्गो^३ द्वादशभिः^३ संयुतं^३ त्रिषष्ट्या^३ च ।
 षष्ट्याष्टाभिश्चोनं^३ कुर्वन्नावत्सराद्^३ गणकः ॥ ८४ ॥
 इन्दु^३ विलिप्ता^३ शेषं^३ मंत्राशेषं^३ वा ।
 अथवा मध्यमिष्टं^३ कुर्वन्नावत्सराद्^३ गणकः ॥ ८५ ॥
 जीवविलिप्ता^३ शेषा^३ कुर्जमिदुं^३ भौमलिप्तिकाशेषात्^३ ।
 रविमिदभागशेषा^३ कुर्वन्नावत्सराद्^३ गणकः ॥ ८६ ॥

८३. (घ) (वि०—इसकी क्रमसंख्या ८४ है)

१. ६३ (च) for (३३) २. + ६७ + (च)

(ग) ३. शेषसहितं for (शेषं सहितं)

(च) ४. (वि०—क्रमसंख्या ८४ अंकित है)

(ङ) १. '३३' लुप्त ।

८४. (घ) (वि०—इसकी क्रमसंख्या ८५ है)

(ग) १. २. '३३' पद लुप्त है । ३. वर्ग for (वर्गो)

(च) १. ऽर्क for (३३) ४. (वि०—क्रमसंख्या ८५ अंकित है)

(ङ) ३. 'वर्गो' (लुप्त)

८५. (घ) (वि०—इसकी क्रमसंख्या ८६ है)

१. शेषमंशशेषं वा (ग) शेषाद्रविलिप्ताशेषमंशशेषं वा for (शेषं मंत्राशेषं वा)

(ग) २. इदं for (इन्दु)

(च) १. शेषमंशशेषं वा for (शेषं मंत्राशेषं वा)

३. मध्यममिष्टं for (मध्यमिष्टं) ४. (वि०—यहां क्रमसंख्या ८६ अंकित है)

(ङ) ५. + शेषाद् रविलिप्ता + १. शेषमंशशेषं for (शेषं मंत्राशेषं)

३. मध्यममिष्टं for (मध्यमिष्टं)

८६. (घ) (वि०—इसकी क्रमसंख्या ८७ है)

१. मिदु (ग) (ङ) for (मिद)

(ग) २. जीवविलिप्ताशेषं for (जीवविलिप्ताशेषा)

३. विलिप्तिका for (लिप्तिका) ४. शेषात् (ङ) for (शेषा)

(च) १. द्रविमिदुभाग for (रविमिदभाग)

५. कुर्वन्नावत्सराद्गणकः for (कुर्वन्नावत्सराद्गणकः)

७. (वि०—क्रमसंख्या ८७ अंकित है)

(ङ) २. विलिप्ताशेषात् for (विलिप्ताशेषा)

इष्टग्रहेष्टशेषा^५ द्युगणो गतनिरपवर्तयं^२ संगुणितैः^१ ।
 छेददिनैरधिकोस्मादन्यग्रहशेषमिष्टो वा ॥ ८७ ॥
 निच्छेदभागहारौ ग्रहयोर्भगणादि शेषयोर्द्युगुणात्^३ ।
 यस्मात्तं निच्छेदेनोद्धृतयोर्लब्धयोर्गुणितौ ॥ ८८ ॥
 निच्छेदभागहारौ विपरीतौ तद्युतात्फलस्तस्मात् ।
 शेषेद्युगुणादेवं^४ आदिना प्राग्वदिष्टदिने ॥ ८९ ॥

८७. (घ) (वि०—इसकी क्रमसंख्या ८८ है)

१. 'य' यह मूलपाठ में उपलब्ध नहीं (ग)

(ग) २. निरवर्त for (निरपवर्तयं) ३. संगुणितैः for (संगुणितैः)

(च) २. निरपवर्तसंगुणितैः for (निरपवर्तयं संगुणितैः)

४. (वि०—क्रमसंख्या ८८ है)

(ङ) ५. शेषाद् for (शेषा)

८८. (घ) (वि०—इसकी क्रमसंख्या ८९ है)

१. कंगणात् for (द्युगुणात्) २. द्दृतयो (ग) घृताया for (दृतयो)

(ग) ३. शेषवो द्युगणात् for (शेषयोर्द्युगणात्)

४. यस्मात्तन्न for (यस्मात्तं)

५. लब्धसंगुणितौ for (लब्धयोर्गुणितौ)

(च) १. द्युगणात् (ङ) for (द्युगुणात्) २. नोद्धृतयो for (नोद्धृतयो)

६. (वि०—क्रमसंख्या ८९ अंकित है)

(ङ) ७. निश्छेद for (निच्छेद) १. निश्छेदे for (निच्छेदे)

८. विपरीतौ for (भंगणादि)

५. लब्धसंगुणितौ for (लब्धयोर्गुणितौ)

३. ग्रहयो for (शेषयो)

८९. (घ) (वि०—इसकी क्रमसंख्या ९० है)

१. पुन (ग) पुनः शेषे for (फलस्तस्मात्)

२. द्युगणादेवं (च) (ङ) for (द्युगुणादेवं)

३. आदीनां (ग) (ङ) for (आदिना)

४. ३ द्युगणादेवत्यादीनां for (शेषेद्युगुणादेवं आदिना)

(ग) (वि०—दूसरी पंक्ति "द्युगणा" से आरम्भ होती है)

(च) १. पुनस्तस्मात् (ङ) for (फलस्तस्मात्)

५. (वि०—क्रमसंख्या ९० अंकित है)

(ङ) ६. निश्छेद for (निच्छेद)

द्युगुणमवशेषाद्रविचंद्रौ मध्यमौ स्फुटादथवा ।

एवं तिथिं ग्रहं वा कुर्वन्नावत्सराद् गरुणकः ॥ ६० ॥

एकदिनावमशेषं षट् गरुणमेकरविचन्द्रभरणोत्तमम् ।

शुध्यति भूदिनभक्तं व्येकं चांद्रैस्तदुक्तिरियम् ॥ ६१ ॥

इषुशरकृताष्टदिग्भिः १०८४५५ संगुणितादवमशेषाद् भक्तात् ।

रूपाष्टरसवेदरसशून्यशरगुणैः ३५०६४८१ दिनगणः शेषम् ॥ ६२ ॥

६०. (घ) (वि०—इसकी क्रमसंख्या ६१ है)

१. गरुण for (गुण) (ग) द्युगुणमवमासशेषा for (द्युगुणमवशेषा)

२. मध्यमौ (च) for (मध्यमौ)

(ग) ३. स्फुटादथवा for (स्फुटादथवा) (वि०—इसकी क्रमसंख्या ६० है)

(च) १. द्युगुण for (द्युगुण)

४. (वि०—क्रमसंख्या ६१ अंकित है)

(ङ) १. गुणमवमावशेषा for (गुणमवशेषा)

६१. (घ) (वि०—इसकी क्रमसंख्या ६२ है)

(ग) १. चद्रगुण for (षट्गुण) २. सगणोत्तम for (भरणोत्तम)

३. एकादिना for (एकदिना) ४. भूदिभक्तं for (भूदिनभक्तं)

(च) ५. (वि०—यहां क्रमसंख्या ६२ अंकित है)

(ङ) ३. एकदिनमवमशेषं for (एकदिनावमशेषं)

१. यद्गुणमेक for (षट्गुणमेक)

६२. (घ) (वि०—इसकी क्रमसंख्या ६३ है)

१. दवमशेषकाद् for (दवमशेषाद्भक्तात्)

२. रूपाष्ट वेदरसशून्य (ग) for (रूपाष्टरसवेदरसशून्य)

३. दिनगणः (ङ) (च) for (दिनगणः)

(ग) ४. इषुशरकृताष्टदिग्भिः for (इषुशरकृताष्टदिग्भिः)

५. देवमशेषकाभक्तात् for (दवमशेषाद्भक्तात्)

६. रगुणो for (शरगुणैः)

(च) १. दवमवशेषकाद्भक्तात् for (दवमशेषाद्भक्तात्)

२. वेदरस (ङ) for (रसवेदरस)

८. (वि०—क्रमसंख्या ६३ अंकित है)

(ङ) १. शेषकाद्भक्तात् for (शेषाद्भक्तात्)

जिनरस गोब्धिरद्वगुणा ३२४६२४ छशि वसुकुत रसखभुतरामहृतान् ।

इष्टावमशेषाद्येषं रविभगण शेषं तत् ॥ ६३ ॥

गोगेदुखेश ११०१७६ गुणितद्वक्तान्नखपक्षयम रसेषु गुणैः ३५६२२० ।

शेषमवमावशेषात्तिथयो वमशेषकाद्विकलम् ॥ ६४ ॥

भागकलाविकलैक्यं दृष्ट्वा विकलांतरं न के शेषैः ।

ऐक्यं द्विधांतराधिकहीनं द्विविभाजितं शेषम् ॥ ६५ ॥

६३. (घ) (वि०—इसकी क्रमसंख्या ६४ है)

१. रदगुणा (ग) रसगुणा for (रदगुणा)

२. भूत (ग) (ङ) for (भुत)

३. हृतान् । ३५६४८१ (ग) राहृतात् for (रामहृतान्)

(ग) ४. (वि०—संख्या के अंक लुप्त हैं) ५. शशि (ङ) for (छशि)

५. शेषाद्या for (शेषाद्य)

(च) १. रदगुणा for (रदगुणा) २. भूत for (भुत)

३. रामहृतान् for (रामहृतान्) ७. वि०—यहां क्रमसंख्या ६४ अंकित है)

(ङ) १. गोब्धिरद ३२४६२४ गुणान् for (गोब्धिरद्वगुणा ३२४६२४)

३. हृतात् for (हृतान्) ६. शेषाद्यशेषं for (शेषाद्येषं)

६४. (घ) (वि०—इसकी क्रमसंख्या ६५ है)

१. गुणितद्वक्ता (ग) (च) (ङ) for (गुणितद्वक्ता)

२. '३५६२२०' दूसरी पंक्ति का आरंभ (य) संख्या लुप्त

(ग) ३. गोगेदुखेश for (गोगेदुखेश) ४. संख्या के अंक लुप्त हैं

५. नाख for (न्नख) ६. शेषावमाव for (शेषमवमाव)

(च) ७. गुणैः for (गुणैः)

(वि०—यहां क्रमसंख्या ६५ अंकित है)

(ङ) ३. गोगेदु for (गोगेन्दु)

६५. (घ) (वि०—इसकी क्रमसंख्या ६६ है)

१. वके शेषे (ग) च के शेषे for (नके शेषैः)

२. शेषे (ग) (ङ) for (शेषम्)

(ग) ३. द्विधांतरा for (द्विधांतरा) ४. द्विविभाजितं for (द्विविभाजितं)

(च) १. वकेशेषे for (नके शेषैः) २. शेषे for (शेषम्)

(वि०—क्रमसंख्या ६६ अंकित है)

(ङ) १. च for (न)

६. शेषे for (शेषैः)

३. द्विधांतरा for (द्विधांतरा) ४. च द्विविभाजितं for (द्विविभाजितं)

तद्वर्गांतरमाद्यं^१ तदंतरं^२ चांतरोद्धृत^३ तयुतोन्म^४ ।
 वर्गांतरं विभक्तं^५ ताभ्यां^६ शेषोन्यतो^७ द्युगणः ॥ ६६ ॥
 कृतिसंयोगाद्विगुण^१ छेषयुतिकृति^२ विशोध्य^३ मूलेन^४ ।
 शेष^५ युतिर्युत^६ हीनाद्विहता^७ शेषे^८ पृथक्^९ युक्त्या ॥ ६७ ॥
 शेषवधाद्विहृति^१ गुणा^२ छेषांतरवर्गसंयुतान्मूले^३ ।
 शेषांतरीनयुक्तं^४ दलितं^५ शेषे^६ पृथगभिष्टे ॥ ६८ ॥

६६. (घ) (वि०—इसकी क्रमसंख्या ६७ है)

१. चांतरोद्धृत (ग) (ङ) for (चांतरोद्धृत)

२. द्वा द्वाभ्यां for (ताभ्यां) ३. शेषे ततो (ग) (ङ) for (शेषोन्यतो)

(च) १ चांतरोद्धृत for (चांतरोद्धृत) ४. (वि०—क्रमसंख्या ६७ है)

३. शेषो ततो द्युगणः for (शेषोन्यतो द्युगणः)

(ङ) ५. माद्ये for (माद्यं) २. द्वाभ्यां for (ताभ्यां)

६७. (घ) (वि०—इसकी क्रमसंख्या ६८ है)

१. द्विगुणा (ग) (च) for (द्विगुणा)

२. छेष for (छेष) (ग) छेष कृतियुति for (छेषयुतिकृति)

३. विहृता (ग) विहृता for (द्विहृता)

(ग) ४. कृत संयोगा for (कृतिसंयोगा) ५. पृथग्युक्त्या for (पृथक् युक्त्या)

(च) ६. द्विहृता for (द्विहृता)

६. (वि०—क्रमसंख्या ६८ अंकित)

(ङ) कृतिसंयोगाद् द्विगुणाद्युतिवर्गं प्रोह्य शेषमूलं यत् ।

तेन युतोन्मो योगो दलितः शेषे पृथगभिष्टे ॥ ६८ ॥

for

(कृतिसंयोगाद्विगुण छेषयुतिकृति विशोध्य मूलेन

शेषयुतिर्युतहीना द्विहृता शेषे पृथक् युक्त्या ॥ ६७ ॥)

६८. (घ) (वि०—इसकी क्रमसंख्या ६९ है)

१. विकृति (ग) for (द्विकृति) मूलम् (ग) (ङ) for (मूले)

३. शेषांतरोन (ग) (ङ) for (शेषांतरीन युक्तं)

४. पृथगभिष्टे (ग) (ङ) for (पृथगभिष्टे)

(ङ) १. कृति for (कृति) २. मूलं for (मूले)

४. पृथगभिष्टे for (पृथगभिष्टे)

५. (वि०—क्रमसंख्या ६९ अंकित है)

(ङ) १. वधाद् द्विकृतिगुणाद् for (वधाद्विकृतिगुणा) ६. शेषांतर for (छेषान्तर)

^२सुखमात्रममी ^६प्रश्ना ^१प्रश्नान्यात्सहस्रशः कुर्यात् ।
^३अन्यैर्दत्तात्प्रश्नानुक्तै ^७र्वा साधयेत्कर्णैः ॥ १९६ ॥
 जन संसदि दैवविदां तेजो नाशयति भानुरिव भानाम् ।
^३कुट्टाकारप्रश्नैः ^४पठितैरपि किं पुनर्ज्ञातैः ॥ १०० ॥
 प्रतिसूत्रममी प्रश्नाः पठिताः सोद्देशकेषु सूत्रेषु ।
^१आयाणां ^२अधिकशते ^३कुट्टकोष्टादशोऽध्यायः ॥ १०१ ॥
 इति श्री ब्रह्मगुप्ते अष्टादशोऽध्यायः ।

१९६ (घ) (वि०—इसकी क्रमसंख्या १०० है)

१. प्रश्नानन्या (ग) प्रश्नानन्यान् (ङ) for (प्रश्नान्यात्)

(ग) देव्यान् for (सुखमात्र) ३. दत्तान् for (दत्तात्) ४. त्कर्णैः for (कर्णैः)

(च) १. प्रश्नानन्यान्सहस्रशः (प्रश्नान्यात्सहस्रशः)

(वि०—इसकी क्रमसंख्या १०० अंकित है)

(ङ) २. हृदि वाचममी for (सुखमात्रममी) ६. प्रश्नाः for (प्रश्ना)

३. अन्यैर्दत्तान् for (अन्यैर्दत्तात्) ७. प्रश्नानुक्त्यैवं for (प्रश्नानुक्तैर्वा)

४. कर्णैः for (कर्णैः) (वि०—३. 'हृतान्मात्रममी' इति सुधाकरः)

१००. (घ) (वि०—इसकी क्रम संख्या १०१ है)

१. पुनर्ज्ञातैः (ग) (च) for (पुनर्ज्ञातैः) २. भारिव for (भानुरिव)

३. कुटाकारं for (कुट्टाकार) ४. प्रस्तैः for (प्रश्नैः)

(च) ३. कुटाकार प्रश्नैः for (कुट्टाकार प्रश्नैः)

५. (वि०—यहाँ क्रम संख्या १०१ अंकित है)

(ङ) १. पुनः शतशः for (पुनर्ज्ञातैः)

१०१. (घ) (वि०—इसकी क्रम संख्या १०२ है)

१. आर्याणाम् (ग) आर्या for (आयाणां) २. शतेन कुष्ट for (शते कुट्ट)

३. 'इति' से 'अध्यायः' तक अंकित नहीं है ।

(ग) २. समी प्रश्नाः for (ममी प्रश्नाः) २. शतेन for (शते)

३. इति श्रीब्रह्मसिद्धाते कुट्टकाध्यायाष्टदशमः ॥ १८ ॥ for (इति श्रीब्रह्मगुप्ते-
अष्टादशोऽध्यायः)

(च) १. आर्याणां for (आयाणां)

३. "इति" से "अध्यायः" लुप्त (केवल "श्री" अंकित है)

५. (वि०—क्रमसंख्या १०२ अंकित है)

(ङ) १. आर्या for (आयाणां) २. अधिकशतेन for (अधिकशते)

६. कुट्टकाष्टादशो for (कुट्टकोष्टादशो)

अथ शंकुच्छायादिज्ञानाध्यायः

एकोनविंशः

दृष्ट्वा^१ दिनार्द्धघटिका^२ योर्कजो^३ क्षांशकान्त्रीजानाति^४ ।
 उदयांतरघटिकाभिर्ज्ञाता^५ ज्ञेयं^६ स तन्त्रज्ञः ॥ १ ॥
 अस्तांतरघटिकाभिर्यो^७ ज्ञाताज्ञेयमानयति^८ तस्मात् ।
 मध्यगतिं^९ ग्रहभगणाननयति^{१०} तया^{११} स तन्त्रज्ञः ॥ २ ॥
 आनयति^{१२} यस्तमो^{१३} रविशशांक^{१४} मानानि^{१५} दिप^{१६} कौच्यतलात् ।
 शंकुतलांतरभूमिं^{१७} ज्ञाने^{१८} छायां^{१९} स तन्त्रज्ञः ॥ ३ ॥
 छायाद्वितीयाग्रांतर^{२०} विज्ञाने^{२१} वेत्ति^{२२} दीपौच्ये ।
 शंकु^{२३} छायाज्ञो^{२४} वा यच्छायौच्ये^{२५} स तन्त्रज्ञः ॥ ४ ॥

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१. (घ) १. ऽर्कजो (ग) (ङ) for (योर्कजो) २. विजानाति (ग) for (बीजानाति)
 (च) १. योऽर्कजो for (योर्कजो) २. विजानाति for (बीजानाति)
 (ङ) ३. ऽक्षांशकान् for (क्षांशकान्) २. विजानाति for (बीजानाति)
 ४. ज्ञाताज्ञेयं for (ज्ञाता ज्ञेयं)
२. (घ) १. अस्तांतर (ग) for (अस्तांतर) २. मध्यगतिं (च) (ङ) for (मध्यगति)
 (ग) ३. युगभ (ङ) for (ग्रहभ) ४. नानयति (च) (ङ) for (ननयति)
 ५. ततः (ङ) for (तया) (वि०— इसकी क्रम संख्या १ लिखी है)
 (च) १. अस्तांतर घटिकाभिर्यो (ङ) for (अस्तांतरघटिकाभिर्यो)
 (ङ) ६. ज्ञाताज्ञेय for (ज्ञाताज्ञेय)
३. (घ) १. दीपकौच्यतलात् (ग) दीपक शिखोन्याः for (दिपकौच्यतलात्)
 (ग) २. भूमि (ङ) for (भूमि) (वि०— इसकी क्रमसंख्या २ लिखी है)
 (ङ) १. दीपकशिखौच्यत् for (दिपकौच्यतलात्)
४. (घ) १. छायाद्वितीया (ग) for (छायाद्वितीया)
 २. भूमिदीपौच्ये (ग) दीप्यौच्ये for (दीपौच्ये)
 (ग) ३. परभूमेच्छायां for (यच्छायौच्ये) (वि०— इसकी श्लोक संख्या ५ है)
 (च) १. द्वितीया for (द्वितीया)
 (ङ) १. छायाद्वितीयभागान्तर for (छायाद्वितीयाग्रांतर)
 ४. विज्ञानेन for (विज्ञाने) २. दीपौच्यम् for (दीपौच्ये)
 ५. शङ्कुच्छायाज्ञो for (शंकुछायाज्ञो) ३. भूमेच्छायां for (यच्छायौच्ये)

दृष्टिं गृहौच्यज्ञो यः स्तदन्तरज्ञो नराकृते नुजले ।
 गृहभित्त्यग्रे दर्शयति दर्पर्णो वा स तंत्रज्ञः ॥ ५ ॥
 हग्रहतलान्तरजले यो दृष्ट्वाग्रं गृहस्य भूमिज्ञः ।
 वेत्ति गृहौच्यं दृष्ट्वा तैलस्थं वा स तंत्रज्ञः ॥ ६ ॥
 वीक्ष्य गृहाग्रं सलिले प्रसार्य सलिलं पुनश्च भूज्ञाने ।
 भ्रानयति जलाद्भूमिं गृहस्य चौच्यं स तंत्रज्ञः ॥ ७ ॥
 ज्ञातै छाया पुरुषै विज्ञाते तोय कुघयो विवरे ।
 कुट्टेर्कं तेजसो यो वेत्थारूढः स तंत्रज्ञः ॥ ८ ॥

५. (घ) १. नराकृते (ग) for (नराकृते) २. नु (ग) (ङ) for (नु)
 ३. गृहभित्त्यग्रे (ग) गृहभित्त्यग्रे (ङ) for (गृहभित्त्यग्रे)
 (ग) ४. दृष्टग्रहौच्यज्ञो for (दृष्टिगृहौच्यज्ञो) ५. दर्पर्णो (ङ) for (दर्पर्णो)
 (वि०—इसकी श्लोक संख्या ४ है)
 (च) १. नराकृते for (नराकृते)
 (ङ) ४. दृष्टग्रहौच्यज्ञो for (दृष्टिगृहौच्यज्ञो) ६. यस्तदन्तरज्ञो for (यः स्तदन्तरज्ञो)
 १. निरीक्ष्यते for (नराकृते)
६. (घ) १. नृग्रह दृग्रहनलान्तर (ङ) for (हग्रह तलान्तर)
 २. गृहस्य (ग) (च) (ङ) for (ग्रहस्य)
 ३. गृहौच्यं (ग) गृहौच्यं (च) (ङ) for (ग्रहौच्यं)
 (ग) ४. जलयो for (जले यो) ५. दृष्ट्वाग्रं (ङ) for (दृष्ट्वाग्रं)
 ६. व for (वा)
 (च) १. दृग्रहतलान्तर for (हग्रहतलान्तर)
 (ङ) १. दृष्ट्वा गृहतलान्तर for (हग्रहतलान्तर) ४. जालभो for (जले यो)
७. (घ) १. गृहाग्रं (ग) (च) (ङ) for (ग्रहाग्रं) २. भूमि (ग) (च) (ङ) for (भूमि)
 ३. गृहस्य (ग) (च) (ङ) for (ग्रहस्य)
 (ग) ४. पुनः स्वभूज्ञाने (ङ) for (पुनश्च भू ज्ञाने) ५. वीक्ष्य for (चौच्यं)
 (ङ) ६. वीक्ष्य for (वीक्ष्य)
८. (घ) १. कुडचयोविवरे (ङ) for (कुघयोविवरे)
 २. कुडचैर्कं (ग) कुघैर्का for (कुट्टेर्कं)
 ३. वेत्थारूढि (ग) वेत्थारूढः for (वेत्थारूढः) (ग) ४. ज्ञाते for (ज्ञातै)
 ५. पुरुषै (ङ) for (पुरुषै) ६. विज्ञातै for (विज्ञाते)
 (च) १. कुडचयो for (कुघयो) २. कुट्टेर्कं for (कुट्टेर्कं)
 (ङ) १. ज्ञातैछाया for (ज्ञातै छाया)
 २. कुडचैर्कं for (कुट्टेर्कं) ३. वेत्थारूढि for (वेत्थारूढः)

इष्ट दिवसाद्धं घटिका घटिका च दशकांतरं प्राणाः ।
 तद्विवसचरप्राणास्तेरक्षं साधयेत्प्राग्वत् ॥ ९ ॥
 ज्ञातः सभाद्धं उदयैरस्तान्तरनाडिकाभिरधिको नः ।
 ज्ञातात्पूर्वापरयोर्ज्ञेयो भाद्धौनके ज्ञेयः ॥ १० ॥
 ज्ञातज्ञेयग्रहयोरुदयान्तरनाडिकाभिरधिकोनः ।
 उदयैर्ज्ञातो ज्ञाताज्ञेये प्रागधरयोर्ज्ञेयः ॥ ११ ॥
 ज्ञातं कृत्वा मध्यं भूयोन्यदिने तदन्तरं भुक्तिः ।
 त्रैराशिकेन मुत्तया कल्पग्रहमंडलानयनम् ॥ १२ ॥
 स्थित्यर्द्धाद्विपरीतं तमः प्रमाणं स्फुटं ग्रहणे ।
 मानोदयाद्रवौद्धोर्घटिकावयवेन भोदयतः ॥ १३ ॥

९. (घ) १. पंचदशकांतर for (चदशकांतरं)

(ग) २. दशांतर for (दशकांतरं)

३. प्रास्तात् for (प्राग्वत्)

(ङ) शी० + अथोत्तराणि +

१. २. पंचदशांतर for (चदशकांतरं)

१०. (च) (वि०—यह श्लोक यहां ११ वीं क्रमसंख्या पर अंकित है)

१. ज्ञेये for (ज्ञेयो)

२. भाद्धौनको for (भाद्धौनके)

३. ज्ञेयः (ङ) for (ज्ञेयः)

(ङ) (वि०—यहां इसकी क्रमसंख्या ११ है)

११. (घ) १. परयो for (धरयो) (ग) प्रागपरयो for (प्रागधरयो)

(ग) २. स्थान रिक्त है, ३. 'ज्ञेय' अक्षर लुप्त है ४. नम् for (नः)

५. ज्ञातो for (ज्ञातो)

६. ज्ञाताज्ञेय for (ज्ञाताज्ञेये)

७. ज्ञेयः for (ज्ञेयः)

(वि०—इसकी क्रमसंख्या १० है)

(च) १. प्रागपरयो for (प्रागधरयो)

८. (वि०—इसकी क्रमसंख्या १० अंकित है)

(ङ) ६. ज्ञाताज्ञेयः for (ज्ञाताज्ञेये)

१२. (घ) १. भुत्तया (ग) (च) (ङ) for (मुत्तया)

१३. (घ) १. शशिग्रहणे for (स्फुटं ग्रहणे)

दीपतलशंकुतलयोरंतरमिष्टप्रमाणशंकुगुणम् ।
 दीपशिखौच्याच्छंकुं विशोध्य शेषोद्धृतं छाया ॥ १४ ॥
 शंकुवन्तरेण गुणिता छाया छायांतरेण भक्ता भूः ।
 स छाया शंकुगुणा दीपोच्यं छायाया भक्ता ॥ १५ ॥
 ज्ञात्वा शंकुछाया मनुपातात्साधयेत्समुद्धायान् ।
 गृहचैत्यतरु नगानामौच्यं विज्ञायवछायाम् ॥ १६ ॥
 दृष्टि गृहौच्यैवच हृतातदन्तरधरादगौच्य गुणिता ।
 फलभूत्यस्ते तोये प्रतिरूपाग्रं गृहस्य नरात् ॥ १७ ॥

१४. (घ) १. छंकु for (च्छंकु)
 (ग) १. शिखौच्यात् शंकु for (शिखौच्याच्छंकु)
 २. हृतं (च) for (द्धृतं) ३. छायाः for (छाया)
 (च) ४. दीपशिखौच्या for (दीपशिखौच्या)
 (ङ) ४. शिखौच्याच्छङ्कुं for (शिखौच्याच्छंकु)
१५. (घ) १. दीपोच्यं (ग) (ङ) for (दीपोच्यं)
 (ग) २. भक्ताः (च) for (भक्ता)
 (ङ) ३. सच्छाया for (सछाया)
१६. (घ) १. वा (ग) (च) (ङ) for (व)
 (ग) २. मनुपातान् for (मनुपातात्)
 (ङ) ३. शङ्कुच्छाया for (शंकुछाया)
 ४. समुच्छायान् for (समुद्धायान्)
 ५. मौच्यं for (मौच्यं)
१७. (घ) १. गृहौच्यैवच (ग) गृहौच्येक for (गृहौच्यैवच)
 (ग) २. हृता (च) (ङ) for (हृता)
 ३. दगौच्यमं for (धरादगौच्य)
 (च) १. गृहौच्यैवच for (गृहौच्यैवच)
 २. दगौच्य for (दगौच्य) (ङ) ४. युतदृष्टि for (दृष्टि)
 १. गृहौच्य for (गृहौच्यैवच) ५. ह्यन्तर for (तदन्तर)
 ३. भूमिर्दगौच्य for (धरादगौच्य) ६. संगुणिता for (गुणिता)
 ७. न्यस्ते for (न्यस्ते)

गृह पु०षांतर सलिले विक्ष्य गृहाग्रं दृगौच्य संगुणितम् ।

गृहतोयांतरमौच्यं गृहस्य नृजलांतरेण हृतम् ॥ १८ ॥

प्रथमं द्वितीयं नृजलांतरांतरेणोद्धृता जलाय सृतिः ।

दृष्टौच्यं गुणोद्ध्रायस्तोयानृजलांतरगुणा भूः ॥ १९ ॥

छाया पुरुषच्छिन्नं जल कुधांतरं मवाप्तमारुढिः ।

अध्याये विशत्यार्याणामेकोनविशोयम् ॥ २० ॥

इति ब्रह्म गुप्ते छायाध्यायः

एकोनविंशोऽध्यायः समाप्तः

१८. (घ) १. वीक्ष्य (ग) (च) (ङ) for (विक्ष्य)

२. गृहाग्रं (ग) (च) (ङ) for (ग्रहाग्रं)

३. हृतम् (ग) (च) (ङ) for (हृतम्)

(ग) ४. सलिल for (सलिले)

५. व्यसंगुणितम् for (दृगौच्यसंगुणितम्)

६. नृजलांतरेण for (नृजलोन्तरेण)

(च) ७. दृगौच्य for (दृगौच्य)

८. मौच्यं for (मौच्यं)

१९. (घ) १. जलापसृतिः (ग) (ङ) for (जलाय सृतिः)

(ग) २. नृजलांतरांतरा for (नृजलांतर) ३. छाया for (छाया)

४. स्तोयन्नृजलांतर for (स्तोयानृजलांतर)

(च) ५. प्रथ for (प्रथमं)

६. द्वितीय for (द्वितीय)

(ङ) ७. दृष्टौच्य for (दृष्टौच्य)

८. गुणोद्ध्राय for (गुणोद्ध्राय)

२०. (घ) १. बल for (जल)

३. कुधांतर (च) for (कुधांतर)

३. अध्यायो (ग) अध्याय for (अध्याये)

४. 'इति' से 'समाप्त' तक पाठ उपलब्ध नहीं (ग)

(ग) ५. मवामारुढिः for (मवाप्तमारुढिः) ६. विशत्यार्याणा for (विशत्यार्याणा)

७. मेकान विशोयम् for (मेकोनविशोयम्)

(च) ३. अध्यायो (ङ) for (अध्याये) ४. 'इति' से 'समाप्त' तक पाठ लुप्त ।

(ङ) ८. च्छिन्नं for (छिन्नं)

२. कुधांतर for (कुधांतर)

४. इति श्री ब्राह्मस्फुटसिद्धान्ते शकुच्छायादिज्ञानं नामैकोनविंशोऽध्यायः for

(इति ब्रह्मगुप्ते छायाध्यायः)

अथ छन्दश्चित्युत्तराध्यायो

विशतितमः

ऋग्वर्गः पर्यायः समूह योगो वयुक्षु गुम्भेषु ।
 सोपाः प्राग्वत्पादाश्चतुष्कका शेष युक्तोत्थः ॥ १ ॥
 एकैक युत विहीना वाद्यंतौ तद्विपर्ययो यावत् ।
 वर्गादिष्व समयुजः क्रमोक्रमाद्वर्द्धयेत्पादान् ॥ २ ॥
 एकैकेनद्वाद्या न सोपेष्टधिकेषु तत्प्रविष्टेषु ।
 वर्गादिरीष्टांत प्रस्तारो भवति यवमध्यात् ॥ ३ ॥

१. (घ) १. रिग्वर्गः (ग) ऋग्वर्कः for (ऋग्वर्गः)
 २. पर्यायः (ग) (च) (ङ) for (पर्यायः) ३. योगा (ङ) for (योगो)
 ४. वयुक्षु (ग) वयुक्ष for (वयुक्षु)
 ५. चतुष्ककाः (ग) (च) (ङ) for (श्चतुष्कका)
 (ग) ६. प्रागृत for (प्राग्वत्) ७. युक्तोत्थः for (युक्तोत्थः)
 (ङ) ८. सोपाः for (सोपाः) ९. प्राप्तादा for (पादा)
२. (घ) १. विहीनाद्यंतौ (ग) वाद्यंतौ for (वाद्यंतौ)
 २. क्रमोत्क्रमाद् (ग) क्रमात् (ङ) for (क्रमोक्रमाद्)
 (ग) ३. एकादि (ङ) for (एकैक) ४. तद्विपर्यायो for (तद्विपर्ययो)
 ५. वर्गादिषु (ङ) for (वर्गादिष्व) ६. विषमयुजाक्रमो for (समभुजः)
 (च) २. क्रमोत्क्रमाद्वर्द्धयेत् for (क्रमोक्रमाद्वर्द्धयेत्)
 (ङ) ४. तद्विपर्ययो for (तद्विपर्ययो) ६. विषमयुजां for (समभुजः)
३. (घ) १. सोपेष्टधिकेषु for (न सोपेष्टधिकेषु)
 २. भीष्टां (ग) वर्गादिरभीष्टांतः for (वर्गादिरीष्टांतः)
 (ग) ३. द्वाद्याः for (द्वाद्या) ४. सोपेष्टधिकेषु for (न सोपेष्टधिकेषु)
 ५. तत्प्रविष्टेषु (ङ) for (तत्प्रविष्टेषु)
 ६. मध्यः (ङ) for (मध्यात्)
 (च) १. नसोपेष्टधिकेषु for (नसोपेष्टधिकेषु)
 (ङ) ३. द्वाद्याद्याः for (द्वाद्या) १. सोपेष्टधिकेषु for (न सोपेष्टधिकेषु)
 २. वर्गादिरभीष्टान्तः for (वर्गादिरीष्टांतः)

१
अनोचोद्विपदाग्रं विपदाद्या नामतः पृथक् संख्या ।

तच्छोधोव्येकः पृथगंतापमूर्द्धं युतम् ॥ ४ ॥

यावत्पादाव्येका गच्छद्वर्गोष्वथैकं वृद्धेषु ।

रूपाद्युद्धृतघाते वर्गाद्यानां परा संख्या ॥ ५ ॥

रूपाधिकयोर्द्धं विषमे पूर्वः समेषु पादाद्धं ।

आद्या द्विगुणाव्येकां गुलान्यधस्तस्य सर्वेषाम् ॥ ६ ॥

मध्येस्तथाद्धहीनैः क्रमपादैर्व्यस्तं तुल्य पांदाद्यैः ।

विषमेष्ट्वेकं मध्ये प्रोह्याद्यान्यतः कुर्यात् ॥ ७ ॥

४. (घ) १. अनोन्यो (ग) अनोद्विपदाग्रं for (अनो चो)

२. ताश्चांधोव्येक for (तच्छोधोव्येकः) ३. 'धे' लुप्त

(ग) ४. विपदाद्यानाममधः for (विपदाद्यानामतः) २. व्येकः for (व्येकः)

५. पृथगंताद्रूपमूर्द्धंयुतम् for (पृथगंतापमूर्द्धंयुतम्)

(च) १. अनोचो for (अनोचो) २. तांछोधोथे for (तच्छोधोथे)

५. पृथगंताद्रूपमूर्द्धंयुतं for (पृथगंतापमूर्द्धंयुतम्)

(ङ) १. अनोन्यो for (अनो चो)

४. विपदाद्यानाममधः for (विपदाद्यानामतः) २. तच्छोधो for (तच्छोधोथे)

५. पृथगंताद्रूपमूर्द्धंयुतम् for (पृथगंतापमूर्द्धंयुतम्)

५. (घ) १. चैक for (थैक)

(ग) २. व्येको for (व्येका)

३. गच्छद्वर्गोष्वथैकवृद्धेषु for (गच्छद्वर्गोष्वथैकवृद्धेषु)

(ङ) ४. गच्छाद् for (गच्छेद्) ५. रूपाद्युद्धृतघाते for (रूपाद्युद्धृतघाते)

६. (घ) १. रूपाधिकपादार्धे (ङ) (ग) रूपाधिकापादार्धे for (रूपाधिकयोर्द्धं)

३. अज्या for (आद्या)

(ग) २. विषमेष्ट्वेकं समेषु पादा for (विषमेपूर्वः)

३. अर्द्धाद्विगुणाव्येकां (ङ) for (आद्याद्विगुणाव्येकां)

(च) १. रूपाधिकपादाद्धं for (रूपाधिकयाद्धं) ३. अद्या for (आद्या)

(ङ) २. विषमेष्ट्वेकः for (विषमेपूर्वः) ४. गुलान्यधस्तस्य for (गुलान्यधस्तस्य)

७. (घ) १. (मध्यं) (ग) मध्यं for (मध्ये) २. मधे for (मध्ये)

२. प्रोह्याद्यान्यतः for (प्रोह्याद्यान्यतः) ४. र्यात् for (कुर्यात्)

(ग) ५. व्यस्तुल्य for (व्यस्तुल्य)

(ङ) १. माध्यं for (मध्ये) ६. पादाद्यः for (पादाद्यैः)

७. विषमेष्ट्वेकं for (विषमेष्ट्वेकं)

संवक्रम तुलाद्यैर्न्यासोप्यधिको विशोधितश्चाधः ।
 सांख्यैक्यं तादृक् तादृक् प्रथमस्त्रिरहितो नष्टे ॥ ८ ॥
 माध्यैः कृतैश्चदलितं सम संख्यायां क्रमोक्रमाक्षेप्यम् ।
 विषमायां व्येकायां दलं क्रमादुक्रमात् सैकम् ॥ ९ ॥
 समसंख्यायां सोपात् क्रमोक्रमाभ्यां तथैव विषमाम्याम् ।
 कल्पोपविते दृष्टे प्रथमः शेषाक्षराण्यन्ते ॥ १० ॥
 समदलसम विषमाणां संख्यापादाद्ध सर्वकल्पवधः ।
 स्वाद्य वधोन्यैः पादैः स्वपरस्य प्राग्वधः सैकैः ॥ ११ ॥

८. (घ) १. तुल्याद्यै (ग) (ङ) for (तुलाद्यै)
 २. व्यधिको (ग) नसोभ्यधिको (ङ) for (न्यासोप्यधिको)
 (ग) ३. सैकक्रमं for (सैवक्रम) ४. संख्यैक्यं (ङ) for (सांख्यैक्यं)
 ५. तादृक् यादृक् for (तादृक् तादृक्) ६. यस्त्रि for (प्रथमस्त्रि)
 (च) ३. सैकक्रम (ङ) for (सैवक्रम) ४. सोख्यैक्यं for (सांख्यैक्यं)
 (ङ) ७. यादृक् for (तादृक्)
९. (घ) १. माध्यैः (ग) मध्यैः for (माध्यैः)
 २. क्रमोत्क्रमा (ग) (च) for (क्रमोक्रमा)
 ३. दुत्क्रमात् (च) for (दुत्क्रमात्)
 (ग) ४. दलितैः (च) (ङ) for (दलितैः) ५. त्क्षेप्यम् for (क्षेप्यम्)
 (ङ) २. क्रमोत्क्रमात् for (क्रमोक्रमा) ५. क्षेप्यम् for (क्षेप्यम्)
१०. (घ) १. संक्षाया for (संख्यायां)
 २. क्रमोत्क्रमाभ्यां (ङ) (ग) क्रमोत्क्रमाभ्यां for (क्रमोक्रमाभ्यां)
 ३. कल्पोपवितो (ग) कल्पोपविते for (कल्पोपविते)
 ४. शेषाक्षराण्यन्ते for (शेषाक्षराण्यन्ते)
 (ग) ५. दृष्टे for (दृष्टे) ६. शेषाः for (शेषा)
 (च) २. क्रमोत्क्रमाभ्यां for (क्रमोक्रमाभ्याम्)
 (ङ) ७. सोपान for (सोपात्) ८. विषमाम्याम् for (विषमाम्याम्)
 ३. कल्पोपविते for (कल्पोपविते)
११. (घ) १. संक्षापादं (ग) संख्यापा for (संख्या)
 (ग) २. स्वाद्य for (स्वाद्य)
 (ङ) १. संख्यापादार्धं for (संख्यापादार्धं)
 २. स्वाद्यवधोन्यैः for (स्वाद्यवधोन्यैः)

आद्यादनन्तरोधः कल्पोत्य तुल्य माद्य कल्प प्राक् ।
 न्यासो वर्गोन्योन्य प्रस्तारेद्धं समविषमाणाम् ॥ १२ ॥
 नष्टांत्यास्वाधस्थो न कल्प घातो अर्द्धं तुल्य विषमाणाम् ।
 व्येकः पृथक् स्ववर्गोद्धृतः फलं तुल्य कल्पानाम् ॥ १३ ॥
 उद्दिष्टे कल्प कृतो तीतै प्रथम फलस्वरूपेभ्यः ।
 असकृद्वर्गांश्च युते सैके वार्द्धं सम विषमाणाम् ॥ १४ ॥

१२. (घ) १. कल्पोऽनु (ग) कल्पोन्य for (कल्पोत्य)
 २. न्यासो वर्गो (ग) न्यासो च गोभ्यो न for (न्यासो वर्गो)
 ३. न्योन्य for (न्योन्य)
 ४. प्रस्तारेऽर्धं (ग) (च) for (प्रस्तारेद्धं)
 (ग) ५. कल्पः for (कल्प)
 (च) १. काल्पोऽन्यतुल्य for (कल्पोत्यतुल्य) ३. न्योन for (न्योन्य)
 (ङ) ६. दनन्तरोधः for (दनन्तरोधः)
 १. कल्पोऽन्यतुल्यमाद्यः for (कल्पोत्यतुल्यमाद्य)
 ५. 'कल्प' लुप्त ।
 ४. प्रस्तारोऽर्धं for (प्रस्तारेद्धं)
 ३. न्योनः for (न्योन्य)
१३. (घ) १. नष्टांत्याश्चोस्थोन for (नष्टांत्यास्वाधस्थोन)
 २. र्द्धं (ग) (च) (ङ) र्धं for (अर्द्धं) ३. वर्गो for (वर्गो)
 (ग) १. नाष्टांत्यात् for (नष्टांत्) ५. ककल्प for (नकल्पा)
 ६. तुविषमाणाम् for (तुल्यविषमाणाम्) ७. दृतफलः for (दृतः फलं)
 (ङ) १. नष्टेऽन्यात् for (नष्टांत्पा)
१४. (घ) १. कृतेऽतीतैः (ग) हृतेऽतीतैः (ङ) for (कृतोतीतैः)
 २. फले (ङ) for (फल)
 ३. वर्गांश्च (ग) व्यसकृद्वर्गांश्च for (असकृद्वर्गांश्च)
 (ग) ४. उद्दिष्ट for (उद्दिष्टे) ५. चार्धं for (वार्द्धं)
 (च) १. कृतेऽतीतैः for (कृतोतीतैः)
 (ङ) ६. प्रथमः for (प्रथम) ५. वार्धं for (वार्द्धं)

कल्पेषु^१ पृथुगुरु^४ लघुतुल्यवधैक्यं^५ गुरु लघुनि यवमध्ये ।

दलसम विषम लघुनि स्वद्य^३ लघूनानि विषमेषु ॥ १५ ॥

ध्व्यापाः^१ कोष्टक वृद्ध्या लघु संख्यैकादि भाजिताः प्राग्वत् ।

विषमे ज्याघल दूनो^४ लघूनो लघुभिर्मैरुः^५ समादीनाम् ॥ १६ ॥

एकद्विकयोः^२ परतो द्वि संगुणो नंतरो द्विरूपोधः ।

वर्गापराद्योनोदल समविषमाणां ध्वजो लघुभिः ॥ १७ ॥

लघु संख्यादौ परतो दलिता धोघश्च^३ शुष्यति^५ हताद्यैः ।

द्विगुणान्तैः^४ संख्यै^५ शुद्धैर्वर्ग परैर्मंदरो लघुभिः ॥ १८ ॥

१५. (घ) १. कल्पपृथुगुरु for (कल्पेषु) २. लघूनि for (लघुनि)

३. स्वाद्य (च) for (स्वद्य)

(ग) १. कल्पेषु for (कल्पेषु) ४. पृथुगुरुलघु (ङ) for (पृथुगुरुलघु)

५. संख्यैकादिभाजिताः प्राग्वत् (ङ) for (तुल्यवधैक्यं गुरुलघुनि यवमध्ये)

६. विषमेष्वाद्यलघूनो लघुभिर्मैरुः समादीनाम् ॥ १५ ॥ (ङ)

for

(दलसम विषमलघुनि स्वद्य लघूनानि विषमेषु)

(च) २. लघूनि for (लघुनि)

१६. (घ) १. द्वाद्याः (च) for (ध्व्यापाः) २. वृद्धा (च) for (वृद्ध्या)

३. लघू (च) for (लघु) ४. ज्याद्य for (ज्याघ)

(च) ४. द्याद्यल for (ज्याद्यल) ५. 'लघूनो' लुप्त ।

(ङ) यह श्लोक यहां उपलब्ध नहीं ।

१७. (घ) १. वर्ग (ग) for (वर्गा)

(ग) २. द्वितयोः (ङ) for (द्विकयोः) ३. चराद्यो for (पराद्यो)

(च) १. वर्ग (ङ) for (वर्गा) ४. पराद्यां for (पराद्यो)

(ङ) (वि०—इसकी क्रमसंख्या १६ है) ४. अनन्तरा for (नंतरो)

१८. (घ) १. यरै for (परै)

(ग) २. संख्यापद दलिता परतो (ङ) for (संख्यादौ परतो दलिता)

३. हताद्यैः for (हताद्यैः) ४. द्विगुणान्तैः for (द्विगुणान्तैः)

५. शुद्धैः वर्ग for (शुद्धैर्वर्ग)

(च) ६. ध्येवश्च for (धोघश्च) ७. लघुभि for (लघुभिः)

(वि०—इसकी क्रमसंख्या १७ है)

३. हताद्यैः for (हताद्यैः)

६. ध्येवश्च for (धोघश्च)

८. 'संख्यै' लुप्त ।

कृत्वाधोधः कल्पान्ये काद्येकोत्तरानधः शेषात् ।

खात्परतां तैकमधः प्रस्तारा द्युक्त वदीहाद्यैः ॥ १६ ॥

गुरुषष्ट्यैका विघटि द्विगुणा व्येकांगुलानि संख्याद्वा ।

विंशति रायां विंश छंदश्चितुत्तराध्यायः ॥ २० ॥

इति ब्रह्म गुप्ते छंदश्चित्युत्तराध्यायः ॥ २० ॥ अध्यायः समाप्तः

विंशतितमः समाप्तः ।

६. (घ) १. कल्पानेका for (कल्पान्येका)

२. धनः (ग) नघस्तेषाम् (ङ) for (नघः शेषात्)

३. खात्परतोत्यैक (ग) खात्परतोत्यैकमधः for (स्वात्परतो जन्यैकमधः)

४. वदीहाद्यैः (ग) वदीहाद्यैः for (वदीहाद्यैः)

(च) ५. ध्येधः for (घोधः)

१. कल्पानेकाद्येकोत्तरानधः for (कल्पान्येकाद्येकोत्तरानधः)

३. परतांत्यैकमधः for (परतांतैकमधः)

४. वदीहाद्यैः for (वदीहाद्यैः)

(ङ) (वि०—इसकी क्रमसंख्या १८ है)

१. कल्पान्येका for (कल्पान्येका) ४. द्युक्तवदीहाद्यैः for (द्युक्तवदीहाद्यैः)

२०. (घ) १. विघटी द्विगुणाद्ये (ग) विघटी for (विघटि) २. स्या (ग) for (द्वा)

३. विशच्छंद (ग) विशच्छंद for (विशच्छंद)

४. श्चित्युत्तरोऽध्यायः (ग) (ङ) (श्चित्युत्तरोऽध्यायः)

५. 'इति' से 'समाप्त' तक पाठ उपलब्ध नहीं है । (ग)

(ग) ६. विंशति for (विंशति)

(च) १. विघटी for (विघटि) २. संख्याध्या for (संख्याद्वा)

३. श्चित्युत्तराध्यायः for (श्चित्युत्तराध्यायः)

५. 'इति' से 'समाप्त' होने तक लुप्त ।

(ङ) (वि०—इसकी क्रमसंख्या १९ है)

७. गुरुषष्ट्यैका for (गुरुषष्ट्यैका)

१. निघटीद्विगुणा for (विघटिद्विगुणा)

८. न्येकांगुलानि for (व्येकांगुलानि) २. संख्या स्यात् for (संख्याद्वा)

६. द्वाविंशतिरायाणां for (विंशतिरायांविंश)

अथ गोलाध्यायो नाम

एकविंशतितमः

ग्रह नक्षत्रभ्रमणं न समं सर्वत्र भवति भूस्थानम् ।
 तद्विज्ञानं गोलाद्यतस्ततो गोलमभिधास्ये ॥ १ ॥
 शशि बुध सितार्कं कुज गुरु शनि कक्षविष्टितोभ कक्षांतः ।
 भूगोलः सत्वानां शुभाशुभैः कर्मभिरूपात्तः ॥ २ ॥
 खेभूगोलस्तदुपरि मेरौ देवाः स्थितास्तले दैत्याः
 खे भगणाक्षाग्रस्तावु पर्यधश्चा ध्रुवौ तेषाम् ॥ ३ ॥
 ध्रुवयो विद्वंसं व्यगम मराणां क्षितिजसंस्थमुडुचक्रम् ।
 अपसव्यगमसुराणां भ्रमति प्रवहानि लाक्षिप्तम् ॥ ४ ॥

१. (घ) १. भूस्थानाम् (ङ) for (भूस्थानम्)
 २. धास्येः for (धास्ये)
 (ग) ३. 'भवति' पद यहां अंकित नहीं है ।
२. (घ) १. कक्ष्या (ग) कक्षा for (कक्ष)
 २. चेष्टितो (ग) वेष्टितो for (विष्टितो)
 (ग) ३. भक्षांत for (भकक्षांतः)
 (च) ४. सितार्क for (सितार्कं)
 १. कक्ष्यावेष्टितो for (कक्षविष्टितो)
 (ङ) १. कक्षावेष्टितो for (कक्षविष्टितो)
३. (घ) १. षे for (खे)
 २. स्थावुपर्यधश्च (ङ) (ग) तावुपर्यधश्च for (स्तावुपर्यधश्चा)
 (ग) ३. स्थिताः स्तल for (स्थितास्तले) ४. ध्रुवौ for (ध्रुवो)
 (च) २. क्षाग्रस्तावुपर्यधश्चा for (क्षाग्रस्तावुपर्यधश्चा)
४. (घ) १. वंद्स (ग) बंदः for (विद्वंस)
 (ग) २. क्षिति for (क्षितिज)
 (च) १. वंद्स for (विद्वंस)
 (ङ) १. बंद for (विद्व)

अन्यत्र सर्वतो दिशि^१मुन्नमति^२भयं जरोध्रुवो भ्रमति^३ लंकायाः ।

मुहु^४चक्रं^५पूर्वापरगं ध्रुवौ क्षितिजे ॥ ५ ॥

देवा^१सव्यगम सुराः पश्यन्त्यपसव्यगं^२रवि क्षितिजे ।

विषुवति समपश्चिमगं^३निरक्षदेशास्थिताः पुरुषाः^४ ॥ ६ ॥

सौम्यमपमण्डलाद्धं^२मेषाद्यं^३सव्यगं^४सदादेवाः ।

पश्यन्ति तुलाद्यद्धं दक्षिणमप सव्यगं दैत्याः^१ ॥ ७ ॥

पश्यन्ति देवदैत्या रविवर्षाद्धिभुदितं सकृत्सूर्यम् ।

शशिगाः^१शशिमासाद्धं पितरोभूस्थानराः स्वदिवम्^२ ॥ ८ ॥

भूपरिधि तूर्यभागं^१लंकाभूमस्तकाक्षितितलाच्च ।

लंकोत्तरतोवन्ती भूपरिधेः पञ्च दशभागैः^३ ॥ ९ ॥

५. (घ) १. दिश (ग) दिशिमुन्नमति for (दिशिमुन्नमति)
 २. तपंजरो for (भयंजरो) ३. नमति (ग) (ङ) for (भ्रमति)
 ४. 'लंकाया' दूसरी पंक्ति का पहलापद (ग) (ङ)
 ५. मुहुचक्रं (च) (ङ) for (मुहुचक्रं)
 (च) ३. नमति for (भ्रमति)
 ४. लंकाया (ङ) for (लंकायाः) ५. मुहुचक्रं for (मुहुचक्रं)
 (ङ) १. दिशमुन्नमति for (दिशिमुन्नमति) २. भयंजरो for (भयंजरो)
 ६. (घ) १. देवाः (ग) (च)(ङ) for (देवा) २. सव्य गरवि for (सव्यगं रवि)
 ३. तिरक्ष for (निरक्ष) ४. देशस्थिताः (ग) (च) (ङ) for (देशास्थिताः)
 (ग) ५. सुरा for (सुराः) (च) ६. पुरुषाः for (पुरुषाः)
 ७. (घ) १. दैत्या (च) for (दैत्याः) (ग) २. मण्डलाद्धं for (मंडलाद्धं)
 ३. मेषाद्यं for (मेष्वाद्यं) ४. मंसदा for (गंसदा)
 (ङ) २. मपमंडलार्धं for (मपमंडलाद्धं)
 ८. (घ) १. शशि (ग) शशि (च) (ङ) for (शशि)
 २. स्वदिनम् (ङ) for (स्वदिवम्) (ङ) ३. वर्षार्धं for (वर्षाद्धं)
 ९. (घ) १. चतुर्भागं (ग) तूर्यं for (तूर्यभागं)
 २. स्वन्ती (ङ) (ग) लंकोत्तरतोवन्ती for (लंकोत्तरतोवन्ती)
 ३. भागैः (ग) for (भागैः) (ग) ४. लंका for (लङ्का)
 ५. त्क्षिति for (क्षिति) (च) १. चतुर्भागं for (तूर्यभागं)
 २. स्वन्ती for (वन्ती) (ङ) १. तूर्यभागे for (तूर्यभागैः)
 ६. भूमस्तकात् for (भूमस्तका) ३. दशभागैः for (दशभागैः)

अक्षांशभूपरिधि वधान्मंडलभागा सयोजनैर्विषुवत् ।
 तत्भाग योजनैरेवमुपरिस्तयोन्य दनुपातात् ॥ १० ॥
 अंबरयोजनपरिधिः शशिभगणाः शून्यखखजिनाग्नि गुणाः २ ।
 यस्य भगणैर्विभक्तास्तत्कक्षाकोभषष्ट्यंशे ॥ ११ ॥
 भूपरिधि समान षष्ट्या ख परिधि तुल्यानि कल्परविवर्षः ।
 गच्छन्ति योजनानि ग्रहाः स्वकक्षास्तु तुल्यानि ॥ १२ ॥
 भगणस्याधः शनिगुरु भूमिजरविशुक्र सौम्यचंद्राणाम् ।
 कक्षाक्रमेण शीघ्राः शनैश्चराद्याः कलाभुत्तया ॥ १३ ॥

१०. (घ) १. कुपरिधि (ग) (च) (ङ) for (भूपरिधि) २. प्त (ग) (ङ) for (स)
 ३. विषुवत् (ग) (ङ) for (विषुवत्) ४. नत (ग) (ङ) for (तत्)
 ५. सूर्योन्य (च) for (स्तयोन्य)
 (ग) ६. दनुपात् for (दनुपातात्)
 (च) २. भागाप्तयोजनै for (भागासयोजनै)
 ३. विषुवत् for (विषुवत्) ४. नतभाग for (तत्भाग)
 (ङ) (ङ) सूर्योन्य for (स्तयोन्य)
११. (घ) १. विभक्तास्तत् कक्षाकोभ for (विभक्तास्तत् कक्षाकोभ)
 (ग) २. + ३३२४००० +
 (च) ३. कक्षाकोभषष्ट्यंशे for (कक्षाकोभषष्ट्यंशे)
 (ङ) ३. कक्षाकोभ for (कक्षाकोभ) ४. भषष्ट्यंशः for (भषष्ट्यंशे)
१२. (घ) १. भ for (ख) २. स्वकक्षासु for (स्वकक्षास्तु)
 (ग) ३. भपरिधि for (खपरिधि)
 ४. समानि (ङ) for (समान)
 ५. षष्ट्य for (षष्ट्या)
 (च) ५. खष्ट्याष for (षष्ट्या ख)
 (ङ) २. स्वकक्षासु for (स्वकक्षास्तु)
१३. (घ) १. चंद्राणां for (चन्द्राणाम्)
 (ग) २. भगणस्याधः for (भगणस्याधः)
 (ङ) ३. कक्षाः for (कक्षा)

लघवोल्पो राश्यंशा^२ महति महतो^३ ऽल्पवृत्तमल्पेन^४ ।
 पूरयस्ती^५दुर्महता कालेन महाशनैश्चारी ॥१४॥
 यन्मुलं^६ तध्वासो मंडललिप्ता कृतेर्दशहतायाः ।
 तस्याद्धं व्यासाद्धं योजनकर्णप्रमाथार्थम् ॥ १५ ॥
 भगणकलाव्यासाद्धं भवति कलाभिर्यतो न सकलाभिः ।
 ज्यार्द्धानि न स्फुटानि ततः कृतं व्यासदलमन्यत् ॥ १६ ॥
 राश्यष्टांशेषांकांत्यदसंधिभ्यः क्रमोक्रमाकृत्वा ।
 बध्नीयात् सूत्राणि द्वयोर्द्वयो ज्यास्तदर्द्धानि ॥ १७ ॥

१४. (घ) १. लघवोल्पे for (लघवोल्पो) २. राशंशा (च) for (राश्यंशा)
 ३. महतो (ग) (ङ) for (महतो)
 ४. पूरयस्तीदुर्महता (ग) पूरयस्तीदुर्महता (ङ) for (पूरयस्तीदुर्महता)
 ५. महाशनैश्चारी (ग) महच्छनैश्चारी (ङ) for (महाशनैश्चारी)
 (ग) ६. ल्पवृत्त for (ऽल्पवृत्त) ७. मन्येन for (मल्पेन)
 (च) ४. पूरयंती दुर्महता for (पूरयंस्तीदुर्महता)
 ५. महाशनैश्चारी for (महाशनैश्चारी)
 (ङ) १. लघवोल्पे for (लघवोल्पो)
१५. (घ) १. तद्व्यासो (ग) (ङ) for (तध्वासो) २. कृतेर्दश (ग) for (कृतेर्दश)
 ३. नस्याद्धं for (तस्याद्धं) ४. व्याद्धं for (व्यासाद्धं)
 ५. कर्णप्रमाथार्थम् (ग) (च) कर्ण प्रमाथार्थम् for (कर्ण प्रमाथार्थम्)
 (च) १. तद्व्यासो for (तध्वासो) २. दशहतायाः for (दंशहतायाः)
 ४. दद्यासाद्धं for (व्यासाद्धं)
 (ङ) ६. प्रमाथार्थम् for (प्रमाथार्थम्)
१६. (घ) १. + (च) + (ङ)
 (ग) २. यंतोर्यतो for (यं तो न)
 (ङ) ३. सविकलं हि for (सकलाभिः)
१७. (घ) १. ष्वंकांत्यद (ग) for (शेषांकांत्यद)
 २. क्रमोत्क्रमात्कृत्वा (ग) (ङ) for (क्रमोक्रमात्कृत्वा)
 ३. सूत्राणि (ग) (च) (ङ) for (सूत्राणि)
 (च) १. ष्वंकांत्यद for (षांकांत्यद) ग. क्रमोत्क्रमा कृत्वा for (क्रमोक्रमा कृत्वा)
 (ङ) १. राश्यष्टांशेष्वङ्कान् for (राश्यष्टांशेषांकांत्)
 ४. पदसन्धिभ्यः for (यदसंधिभ्यः)

ज्यार्द्धानि ज्यार्द्धानां ज्याखंडान्यंतराणि तन्ये च ।
 व्यस्तान्यं तदेथ विषु^२ क्रमज्या धनुस्ताभ्याम् ॥ १८ ॥
 एक^४ द्वित्रि^३ गुणाया व्यासार्द्धं^१ कृतेः पृथक् चतुर्थेभ्यः ।
 मूलान्यष्ट^५ द्वादश षोडश^६ षडान्यतो न्यानि ॥ १९ ॥
 तुल्यक्रमोत्क्रम^७ समज्या खंडक^८ वर्गं युतिर्भागम् ।
 प्रोह्यानष्टं^९ व्यासार्द्धं^१ वर्गतस्तत्पदे प्रथमं ॥ २० ॥
 तद्दलखण्डानि तदुन^{१०} जिन समानि द्वितीयमुत्पत्तौ ।
 कृतप्रमलैक दिगीशेषु सप्तरसगुणा^{११} नवादीनाम् ॥ २१ ॥
 एवं जीवा खंडान्यल्पानि बहुनि वाद्यखण्डानि ।
 ज्यार्द्धानि वृत्तपरिधेः षष्टचतुर्थत्रिभागानाम् ॥ २२ ॥

१८. (घ) १. तान्येव (ग) (ङ) (च) for (तन्ये च)
 २. वेपु (ग) पादयतेपु for (विषुक्रमज्या)
 (ग) ६. व्यस्तान्यत् for (व्यस्तान्यं) ३. व्यस्तान्यतादय तेषु for (व्यस्तान्यं तदेथ विपु)
 २. तेषुस्त्रक्रमज्या for (विषुक्रमज्या)
 (ङ) ३. व्यस्तान्यन्त्यादय for (व्यस्तान्यं तदेथ)
 २. वेपुस्त्रक्रमज्या for (विषुक्रमज्या)
- १९ (घ) १. कृतेः (ग) (च) (ङ) for (कृतेः) २. षोडश (ग) (च) (ङ) for (षोडश)
 (ग) ३. द्विगुणाया for (द्वित्रिगुणाया) ४. मूलान्यष्ट for (मूलान्यष्ट)
 ५. षडान्यतो for (षडान्यतो)
 (ङ) ५. खण्डान्यतोऽन्यानि for (षडान्यतोऽन्यानि)
२०. (घ) १. तुल्यक्रमोत्क्रम (ग) (च) (ङ) for (तुल्यक्रमोत्क्रम)
 २. चतुर्भागम् (ङ) for (भागम्)
 ३. प्राज्यानष्टं (ग) प्राह्यानष्टं for (प्रोह्यानष्टं)
 (ग) ४. खंड for (खंडक) ५. वर्गस्तत्पदे for (वर्गतस्तत्पदे)
 (च) ३. प्रोह्यानष्टं for (प्रोह्यानष्टं) (ङ) ६. ज्यासम for (समज्या)
२१. (घ) १. तदुन (ग) (च) (ङ) for (तदुन)
 (ग) २. (वि०—'द्वितीय' पद लुप्त है)
 (च) ३. गुणनवादीनाम् (ङ) for (गुणनवादीनाम्)
२२. (घ) १. बहूनि (ग) (च) (ङ) for (बहुनि) २. षडानि (च) for (खण्डानि)
 (ग) ३. ज्यार्द्धानिवृत्तिपरिधेः for (ज्यार्द्धानिवृत्तपरिधेः)
 (के) २. वाद्यखण्डानि for (वाद्यखण्डानि) ३. ज्यार्द्धानि for (ज्यार्द्धानि)

उ^४क्रम समखण्ड^५ गु^१णा^१ध्व्यासादथवा चतुर्थभागाद्यम् ।
 कृ^१त्वोक्त खण्ड^२कानि ज्या^३द्वानियनं नलध्वमस्मात् ॥ २३ ॥
 क^१क्षामंडलभूमध्ये मध्यमः स्वकक्षायाम् ।
 अनुलोमं मंदोच्चात्प्रतिलोमं भ्रमति शीघ्रोच्चात् ॥ २४ ॥
 त्यक्तं तत्परिधौ प्रतिलोमं मन्दोच्चा भ्रमति शीघ्रोच्चात् ।
 अनुलोमं मध्यस्थसमं भूस्थः पश्यति यतो न कक्षायाम् ॥ २५ ॥

२३. (घ) १. गुणाद्व्यासादथवा (ग) (च) (ङ) for (गुणाध्व्यासादथवा)

२. खंडकानि (च) for (खंडकानि)

३. लघ्वस्मात् (ग) लघ्वमस्मात् for (लघ्वमस्मात्)

(ग) ४. उत्क्रम (च) (ङ) for (उत्क्रम) ५. खण्डा for (खण्ड)

६. यामाद्वानियनं for (ज्याद्वानियनं)

(च) २. नलध्वमस्मात् for (नलध्वमस्मात्)

(ङ) ७. भागाद्यत् for (भागाद्यम्) ३. लघ्वस्मात् for (लघ्वमस्मात्)

२४. (घ) १. कक्ष्या for (कक्षा) २. मंडलमध्यं (ग) for (मंडलभूमध्ये)

(च) १. कक्ष्या for (कक्षा) २. मंडलमध्यं for (मंडल)

(ङ) शी० + अथ स्फुट गतिवासना + ३. मध्यं भूमध्ये for (भूमध्ये)

२५. (घ) १. (वि०—यहाँ श्लोक की तीन पंक्तियाँ हैं ।

“नीचोच्चवृत्तमध्यं मध्ये तद्भवति मध्यमः स्वोच्चात्” (च) (ङ) for
 (त्यक्तं तत्परिधौ प्रतिलोमं मंदोच्चा भ्रमति शीघ्रोच्चात्)

२. मध्यसमं (ग) (च) (ङ) for (मध्यस्थसमं)

(ग) १. “नीचोच्चवृत्तमध्यं मध्ये तद्भवति मध्यमः स्वोच्चात्”

तत्परिधौ प्रतिलोमं मंदोच्चात् भवति शीघ्रोच्चात् ॥ २५ ॥

for

(त्यक्तं तत्परिधौ प्रतिलोमं मंदोच्चा भ्रमति शीघ्रोच्चात् । अनुलोमं मध्य-
 स्थसमं भूस्थः पश्यति यतो न कक्षायाम् ॥ २५ ॥)

(च) इस प्रति में ‘घ’ की भाँति श्लोक में तीन पंक्तियाँ हैं—पहली पंक्ति है :
 —“नीचोच्चवृत्तमध्यं मध्ये तद्भवति मध्यमः स्वोच्चात्”

(ङ) (वि०—इस प्रति की पहली पंक्ति ‘नीचोच्चवृत्तमध्यं तद् भ्रमति मध्यगः
 स्वोच्चात्’ उपर्युक्त प्रतियों में छूट गई । और दो श्लोकों की चार पंक्तियों
 में से केवल तीन को सम्मिलित करके एक श्लोक माना गया । आगे के
 श्लोकों में फलतः सर्वत्र इस प्रति की दृष्टि से पूर्व श्लोक का उत्तरार्ध +
 अग्रिम श्लोक का पूर्वार्ध मिलाकर श्लोकों की व्यवस्था की गई है ।

स्पष्टं तन्मध्यांतरमृणं धनं वा तप्तो मध्ये ।
 कोटिफलं व्यासाद्धात्पदयोराद्यंतयो भवत्युपरि ॥ २६ ॥
 द्वितृतीययोर्धतोऽधस्ताष्टुक्तोनं तरतः कोटिः ।
 कर्णस्तद्भुजफलकृतिसंयोग पदं तदुद्धृता त्रिज्या ॥ २७ ॥
 भुजफल गुणिताप्तधनु गुणिते चैवं फलं शीघ्रे ।
 त्रिज्याभक्तः कर्णः परिधिगुणो बाहुकोटिः गुणाकारः ॥ २८ ॥

२६. (घ) १. अष्टं for (स्पष्टं)

२. ततो (ग) गृहे मध्ये ॥ २६ ॥ for (तप्तो मध्ये)

३. भवत्युपरि (ग) (च) (ङ) for (भवत्युपरि)

(ग) इस श्लोक की पहली पंक्ति २६ वें श्लोक की दूसरी पंक्ति है ।

इस श्लोक की दूसरी पंक्ति २७ वें श्लोक की पहली पंक्ति हैं—

(च) २. ततो for (तप्तो)

(ङ) दे० वि० नोट २५ वें श्लोक के अन्तर्गत टिप्पणी में ।

२. गृहे मध्ये for (तप्तो मध्ये)

२७. (घ) १. तद्युक्तोनं (ङ) for (ताष्टुक्तोनं) २. तरतः (ङ) for (तरतः)

(ग) ३. कोटिः ॥ २७ ॥ (ङ) for (कोटिः)

(वि०—इस श्लोक की दूसरी पंक्ति—२८ वें श्लोक की प्रथम पंक्ति है—

४. फलसंयोगं for (फलकृति संयोग)

(च) १. अधस्ताष्टुक्तोनं for (अधस्ताष्टुक्तोनं)

२८. (घ) १. धनुगुणिते for (धनुगुणिते) (ग) गुणितेनैवं फलं शीघ्रे ॥ २८ ॥

२. नैवं for (चैवं)

३. विज्या for (त्रिज्या)

४. गुणो (ग) (ङ) for (गुणो)

५. गुणाकारः (ग) (ङ) for (गुणाकारः)

(ग) इस श्लोक की पहली पंक्ति २८ वें श्लोक की द्वितीय पंक्ति है ।

६. भुजफल for (भुजफल)

७. कोटि (ङ) for (कोटिः)

(च) १. गुणिते for (गुणिते)

४. परिधिगुणो for (परिधिगुणो)

७. कोटि for (कोटिः)

५. गुणाकारः for (गुणाकारः)

(ङ) १. धनुगुणिते for (धनुगुणिते)

२. नैवं for (चैवं)

असकृत्मां^१दे तत्फलमाद्यसमं^३ नात्र कर्णो^४स्मात् ।

प्रतिपादनार्थमुच्चं^२ प्रकल्पितं ग्रहगतेस्तथा पातः ॥ २९ ॥

भुक्त^३रूनाधिकनामानस्यच भवति कर्णवशात् ।

कक्ष्या^४ व्यासार्द्धभुगा मंडललिप्ता विभाजिताकणः ॥ ३० ॥

स्वकलाकर्णेन^१ गुणः कर्णस्त्रिज्याहृतः^२ स्पष्टः ।

मद्दहन^३ जलमयानं^४ विष्कंभा^५ योजनैः कर्नेदुना ॥ ३१ ॥

२९. (घ) १. असकृत्मां (ग) असकृत्मांघे for (असकृत् मांदे)

२. प्रतिपादनार्थमुच्चं for (प्रतिपादनार्थमुच्चं)

(ग) ३. सम for (ममं)

४. कर्णोस्मात् ॥ २९ ॥ (ङ) for (कर्णोस्मात्)

इस श्लोक का उत्तरार्थ, ३० वें श्लोक का पूर्वार्थ है ।

(च) १. असकृत्मांदे for (असकृत्मांदे)

४. कर्णोस्मात् for (कर्णोस्मात्)

(ङ) २. असकृत्मान्दे for (असकृत्मांदे)

३०. (घ) १. तामानस्य (ग) for (नामानस्य)

(ग) २. व स्यात् ॥ ३० ॥ for (वशात्)

३. कक्षा (ङ) for (कक्ष्या)

इस श्लोक का उत्तरार्थ, ३१ वें श्लोक का पूर्वार्थ है ।

(च) १. तामानस्य for (नामानस्य)

(ङ) १. रूनाधिकता for (रूनाधिकना)

४. + इति स्फुटगतिवासना +

३१. (घ) १. हृतः (ग) हृतस्पष्टः ॥ ३१ ॥ for (हतः)

२. मृद्दहन (ग) (ङ) for (मद्दहन)

३. किनेदुनाम् (ग) किनेदुनाम् for (कर्नेदुना)

(ग) ४. मायानां for (मयानं)

इस श्लोक की दूसरी पंक्ति अगले श्लोक की पहली पंक्ति है ।

(च) हृतः for (हतः)

२. मृद्दहन (ङ) for (मद्दहन)

४. जलमयानां (ङ) for (जलमयानं)

३. किनेदुनां for (कर्नेदुना)

(ङ) ५. विष्कंभा for (विष्कंभा)

३. किनेदुनां for (कर्नेदुना)

शशिवसुतिथिभि यमपक्षशररसैः शून्य वस्तु वेदैः ।
 व्यर्क व्याप्तांतर गुणमिदु स्फुट कर्णमर्ककर्णहतम् ॥ ३२ ॥
 प्रोह्य भुवो भुछाया विष्कभश्चंद्रकक्षायाम् ।
 तद्गुणितं व्यासाद्धं शशिकर्णहतं ततः प्रमाणकलाः ॥ ३३ ॥
 एवं त्रिज्या रविशशि विष्कभगुणाः स्वकर्णहताः ।
 भूछायैन्दुश्चंद्रसूर्यं छादयति मानयोगाद्धात् ॥ ३४ ॥

३२. (घ) १. यम (ग) यमपक्षशररसैः ६५२२ for (यमपक्षशररसै)

२. वसु (ग) वसुवेदैः (ङ) for (वस्तुवेदैः)

३. कर्क for (व्यर्क) ४. व्याप्तांतर (ग) for (व्याप्तांतर)

५. हतम् (ग) for (हतम्)

(ग) ६. राशिवसुतिथिभिः १५=१ for (शशिवसुतिथिभिः)

(वि०—इस श्लोक के पूर्वार्ध की समाप्ति पर ३२ संख्या होनी चाहिए परन्तु लिखी हुई ३३ है)

(च) १. यम for (यम) २. वसु for (वस्तु)

३. व्यर्क for (व्यर्क) ४. व्याप्तांतर for (व्याप्तांतर)

५. मर्ककर्णहतं for (मर्ककर्णहतम्)

(ङ) १. यम for (यम)

३३. (घ) १. भूछाया (ग) for (भुछाया)

२. कक्षायाम् (ग) कक्षायाम् ॥ ३४ ॥ for (कक्षायाम्)

३. ततः (ग) (च) (ङ) for (ततः)

(ग) इस श्लोक का उत्तरार्ध अगले श्लोक का पूर्वार्ध है ।

(च) १. प्रोह्यभुवोभूछाया for (प्रोह्यभुवोभुछाया)

(ङ) १. भूछाया for (भुछाया)

३४. (घ) १. तृज्याशशि for (त्रिज्यारविशशि) २. हताः (ग) हता ॥ ३५ ॥ for (हताः)

३. सूर्य (ग) (च) (ङ) for (सूर्य)

४. भूछायैन्दु चंद्रः (ग) भूछायैन्दुचंद्रः for (भूछायैन्दुश्चंद्र)

५. (वि०—यहां पर कोई अंक संख्या नहीं दी)

(ग) ६. गुणाः for (गुणाः)

(वि०—इस श्लोक का उत्तरार्ध ३६ वें श्लोक का पूर्वार्ध है)

(च) २. हताः for (हताः) ४. भूछायैन्दुचंद्रः for (भूछायैन्दुश्चंद्र)

५. (वि०—यहां पर क्रमसंख्या लुप्त है)

(ङ) ४. भूछायैन्दु चन्द्रः for (भूछायैन्दुश्चन्द्र) ६. गुणा for (गुणाः)

विक्षेपो यद्यूनः शुक्लेतर पंच^३ दृश्यंते ।

महदिदो रावरणं कुठ विषाणो यतो संछन्तः ॥ ३५ ॥

अर्द्धच्छिन्नो भानुस्तिक्ष्ण विषाणस्ततो स्याल्पे ।

यदि राहुः प्राग्भादिदु छादयति किं तथा नार्कम् ॥ ३६ ॥

३५. (घ) १. दृश्यंते (ङ) for (दृश्यन्ते)

(यहां ३५ की संख्या अङ्कित है)

२. द्वं संछन्तः (ग) ध्वंसंछन्तः (ङ) ऽर्धं सञ्छन्तः for (संछन्तः)

(ग) ३. पंचं for (पंच)

१. दृश्यंते ॥ ३६ ॥ for (दृश्यन्ते)

४. रादरणं for (रावरणं)

५. कुठ (ङ) for (कुठ)

वि०—इस श्लोक का उत्तरार्ध ३७ वें श्लोक का पूर्वार्ध है)

(च) ६. विक्षेपो for (विक्षेपो)

३. पंचदृश्यंते ३५ for (पंचदृश्यन्ते)

७. महदिदो (ङ) for (महदिदो)

२. यतोर्द्धं for (यतो)

८. (वि०—यहां कोई क्रमसंख्या अंकित नहीं है)

(ङ) ४. रावरणं for (रावरणं)

३६. (घ) १. स्तीक्ष्ण (ग) (ङ) for (स्तिक्ष्ण)

२. ततोऽस्याल्पम् (च) (ङ) for (ततोऽस्याल्पे)

(वि०—यहां क्रमसंख्या ३६ दी है)

३. प्राग्भागादिदु (ग) प्राग्भादिदु for (प्राग्भादिदु)

(ग) २. ततोऽस्याल्पी ॥ ३७ ॥ for (ततोऽस्याल्पे)

(वि०—इस श्लोक का उत्तरार्ध ३८ वें श्लोक का पूर्वार्ध है)

(च) १. स्तीक्ष्ण for (स्तिक्ष्ण)

४. (वि०—यहां कोई क्रमसंख्या नहीं दी, क्योंकि इस प्रति के अनुसार यहां का उत्तरार्ध ३७ वें श्लोक का पूर्वार्ध है ।

(ङ) ५. अर्धच्छिन्नो for (अर्द्धच्छिन्नो)

२. प्राग्भागादिदु for (प्राग्भादिदु)

स्थित्यद्धं^१ महदिन्दो^२ यथा^३ तथा^४ किन्न^५ सूर्यस्य^६ ।
 किं^७ प्रतिविषयं^८ सूर्यो^९ राहुश्चान्यो^{१०} यतो^{११} रविग्रहणो^{१२} ॥ ३७ ॥
 प्रासान्यत्वं^{१३} न ततो^{१४} राहुकृतं^{१५} ग्रहणं^{१६} मर्कटोः^{१७} ।
 एवं^{१८} वराहमिहिरश्रीषेणार्थं^{१९} भटविष्णुचंद्राद्यैः^{२०} ॥ ३८ ॥
 लोक^{२१} विरुद्धमभिहितं^{२२} वेदस्मृतिसंहिताबाह्यम्^{२३} ।
 यद्येवं^{२४} ग्रहणफलं^{२५} गर्गाद्यैः^{२६} संहितामुदयभिहितम्^{२७} ॥ ३९ ॥

३७. (घ) १. स्थित्यद्धं for (स्थित्यद्धं)

२. सूर्यः स्य (यहां क्रमसंख्या ३७ दी है) (ग) सूर्यस्य ॥ ३८ ॥ for (सूर्यस्य)

३. विषयं (ग) विषयं for (विषयं)

(ग) (वि०—इस श्लोक का उत्तरार्ध ३९ वें श्लोक का पूर्वार्ध है ।

४. सूर्यो for (सूर्यो)

(च) ५. यथा (ङ) for (यथा)

२. (वि०—यहां क्रमसंख्या ३७ अंकित है)

६. वि०—यहां कोई क्रमसंख्या नहीं दी है, क्योंकि इस श्लोक का उत्तरार्ध, ३९ वें श्लोक का पूर्वार्ध है । (ङ) १. स्थित्यद्धं for (स्थित्यद्धं)

३८. (घ) १. कृतं (ग) (च) (ङ) for (कृतं)

२. मर्कटोः (ग) मर्कटोः ॥ ३९ ॥ for (मर्कटोः) (यहां ३८ संख्या दी है)

(ग) ३. श्रीषेणाचार्य for (श्रीषेणार्थं)

इस श्लोक का उत्तरार्ध, ४० वें श्लोक का पूर्वार्ध है ।

(च) २. मर्कटोः for (मर्कटोः) (वि०—यहां श्लोक संख्या ३८ अंकित है)

४. यहां क्रमसंख्या लुप्त है, क्योंकि यह ३९ वें श्लोक का पूर्वार्ध है ।

(ङ) २. मर्कटोः for (मर्कटोः)

३९. (घ) १. स्मृत्युवि for (स्मृति) (यहां संख्या ३९ है)

२. संहितासु (ग) (ङ) for (संहितासु)

३. यदि बिहितम् (ग) for (दयभिहितम्)

(ग) ४. संहिताबाह्यम् ॥ ४० ॥ for (संहिताबाह्यम्)

५. यद्येवं ग्रहफलं for (यद्येवं ग्रहणफलं)

(वि०—इस श्लोक का उत्तरार्ध ४१ वें श्लोक का पूर्वार्ध है ।

(च) ४. यहां '३९' की क्रमसंख्या अंकित है । परन्तु उत्तरार्ध के अन्त में कोई क्रमसंख्या अंकित नहीं, क्योंकि उत्तरार्ध, ४० वें श्लोक का पूर्वार्ध माना जाता है ।

(ङ) ३. यदभिहितम् for (दयभिहितम्)

तदभावे^३ होमजपः स्नानादि^४ फलस्य^५ चाभावः ।

राहुकृतं^१ ग्रहराद्वय मागोपालांगनादि सिद्धमिदम् ॥ ४० ॥

बहुफलमिदमपि^२ सिद्धं जपहोमस्नानफलमत्र ।

स्मृतीषुक्तं^३ न स्नानं राहोरन्यत्र दर्शनाद्वात्रौ ॥ ४१ ॥

राहुग्रस्ते सूर्यं सर्वं गंगासमं तोयम् ।

स्वर्भानुरास्तुरिरिन् तमसा वित्याधवेदवाक्यमिदम् ॥ ४२ ॥

४०. (घ) (वि०—यहाँ प्रथम पंक्ति के अन्त में ४० संख्या दी है)

१. कृतं (ग) for (कृतं)

(ग) २. तदभावो for (तदभावे) ३. लुप्त पद है । ४. लुप्त पद है ।

५. फलस्याभावः ॥ ४१ ॥ for (फलस्य चाभावः)

(वि०—इस श्लोक का उत्तरार्ध, अगले श्लोक का पूर्वार्ध है)

६. मागो पालाङ्गना for (मागो पालाङ्गनादि)

(च) ७. यहाँ '४०' क्रमसंख्या अंकित है । ८. यहाँ कोई संख्या अंकित नहीं, क्योंकि यह उत्तरार्ध भाग ४१ वें श्लोक का पूर्वार्ध माना जाता है ।

(ङ) ४. जप for (जपः) ५. स्नानादीनां फलाभावः for (स्नानादि फलस्य चाभावः)

४१. (घ) १. बाहु for (बहु)

२. मंत्र (यहाँ क्रमसंख्या ४१ दी है) (ग) मन्त्र ॥ ४२ ॥ for (मन्त्र ॥ ४१ ॥)

३. स्मृतीषुक्तं (ग) (ङ) for (स्मृतीषुक्तं)

(ग) इस श्लोक का उत्तरार्ध ३३ श्लोक का पूर्वार्ध है

(च) २. यहाँ '४१' क्रमसंख्या दी गई है । ३. स्मृतीषुक्तं for (स्मृतीषुक्तं)

(वि०—इस प्रति के अनुसार इस श्लोक का उत्तरार्ध ४२ वें श्लोक का पूर्वार्ध है अतः यहाँ अन्त में क्रमसंख्या अंकित नहीं है)

४२. (घ) १. सूर्ये (ग) (च) (ङ) for (सूर्ये)

२. (वि०—यहाँ क्रमसंख्या ४२ (ग) ४३ दी है)

३. रासुरि (ग) रासुरि न तमसा for (रास्तु)

४. विव्याध (ग) विव्याध (ङ) for (वित्याध)

(ग) इस श्लोक का उत्तरार्ध अगले श्लोक का पूर्वार्ध है ।

(च) २. (वि०—यहाँ क्रमसंख्या ४२ अंकित है) ३. रासुरिरिन् for (रास्तुरिरिन्)

४. विव्याध for (वित्याध)

यहाँ श्लोक के अन्त में कोई क्रमसंख्या अंकित नहीं क्योंकि यह उत्तरार्ध माना जाता है ।

(ङ) ३. रासु for (रास्तु)

अतिसंहितास्मृतीनां भवति तथैक्यं^१ तदुक्तिरतः^२ ।
 राहुस्तच्छादयति प्रविशति यच्छुक्ल पंच दश्यन्ते ॥ ४३ ॥
 भूछाया तमसीदो वर्प्रदानात्कमलजस्य ।
 चन्द्रोबुभयोधस्थो यदग्निमय भास्करस्य मासांते ॥ ४४ ॥
 छादयति शमिततयो राहु छादयति तत्सवितुः ।
 भूछाया व्याससमः शशिकक्षायां स्थितः शशिग्रहो ॥ ४५ ॥

४३. (घ) १. यथैक्यं (ग) (च) (ङ) for (तथैक्यं)
 २. (वि०—यहाँ क्रमसंख्या ४३ दी है) (च) (ङ)
 (ग) ३. रतः ॥ ४४ ॥ for (रतः)
 ४. यत् शुक्ल पंच दश्यन्ते for (यच्छुक्ल पंचदश्यन्ते)
 (च) (वि०—यहाँ इस श्लोक के अन्त में कोई क्रमसंख्या अंकित नहीं क्योंकि यह उत्तरार्ध यहाँ ४४ वें श्लोक का पूर्वार्ध माना जाता है)
 (ङ) ४. यच्छुक्ल for (यच्छुक्ल)
४४. (घ) १. (वि०—यहाँ क्रमसंख्या ४४ दी है) (च) (ङ)
 २. बुमयो (ग) चन्द्रोबुमयोधस्थः for (चन्द्रोबुभयोधस्थो)
 ३. धस्थो for (धः स्थो)
 (ग) ४. तमसीदो for (तमसीदो)
 ५. कमलाया ने ॥ ४४ ॥ for (कमलजस्य) ६. यदग्निमय for (यदग्निमय)
 (वि०—इस श्लोक का उत्तरार्ध ४५ वें श्लोक का पूर्वार्ध है)
 (च) (वि०—इस श्लोक का उत्तरार्ध ४५ वें श्लोक का पूर्वार्ध है)
 अतएव यहाँ अन्त में कोई क्रमसंख्या अंकित नहीं ।
 (ङ) ५. कमलयोनेः for (कमलजस्य)
 २. चन्द्रोऽबुमयोऽधः स्थो for (चन्द्रोबुभयोधस्थो)
४५. (घ) १. (वि०—यहाँ क्रमसंख्या ४५ अंकित है) (च) (ङ)
 २. सम for (समः)
 (ग) ३. शमिततायो (ङ) for (शमिततयो)
 ४. तच्छवितुः ॥ ४५ ॥ for (तत्सवितुः)
 (वि०—इस श्लोक का उत्तरार्ध, ४६ वें श्लोक का पूर्वार्ध है) (च)
 (च) ३. शमिततायो for (शमिततयो) ५. क्रम संख्या लुप्त
 (ङ) ६. राहुस्तच्छादयति for (राहुस्तच्छादयति)

राहु छादयती^३दु^४ सूर्यग्रहणोर्कमिदु^१ समः ।
 यत्तदधिकं तमोमयराहुव्यासस्य सूर्यं द्रष्टुं^५ तत् ॥ ४६ ॥
 नश्यति भूछायेंदु^२ व्यास समोऽस्माद् भवति राहुः ।
 भूछायानेंदुमतो ग्रहणो छादयति नार्कबिंदुर्वा ॥ ४७ ॥^५
 तत्स्थस्तद्व्याससमो राहु छादयति शशिसूर्यौ^३ ।
 प्राच्यपरं सममंडलमन्यद्याभ्योत्तरं क्षितिजमन्यत् ॥ ४८ ॥^५

४६. (घ) १. मिदुं समः (ग) (च) (for मिदुसमः)

(वि०—यहां क्रमसंख्या ४६ अंकित है)

२. द्रष्टुं तत् (ग) for (द्रष्टुं तत्)

(ग) ३. छादयतीदुं for (छादयतीदुं) ४. सूर्यं for (सूर्यं)

५. 'सूर्ये' लुप्त पद है ।

(वि०—श्लोक का उत्तरार्ध ४७ वें श्लोक का पूर्वार्ध है) (च)

(च) २. द्रष्टुं for (द्रष्टुं) ६. क्रमसंख्या लुप्त

(ङ) ३. राहुश्छादयतीन्दुं for (राहुश्छादयतीन्दुं) २. दृष्टत्वात् for (दृष्टंतत्)

४७. (घ) १. समोऽस्माद् (च) for (समोऽस्माद्)

(वि०—यहां क्रमसंख्या ४७ दी है)

२. भूछायेंदुं for (भूछायानेंदुमतो)

(ग) ३. राहुः ॥४७॥ for (राहुः)

४. मिदुर्वा for (बिंदुर्वा)

(वि०—इस श्लोक का उत्तरार्ध, ४८ वें श्लोक का पूर्वार्ध है) (च)

(च) २. भूछायानेंदुमतो for (भूछायानेंदुमतो) ४. नार्कमिदुवति for (नार्कबिंदुर्वा)

५. क्रम संख्या लुप्त

(ङ) ६. भूछायेन्द्रोर्व्यास for (भूछायेंदुव्यास)

२. भूछायेन्दुमतो for (भूछायानेंदुमतो)

४८. (घ) १. तद्व्यास (ग) (ङ) for (तद्व्यास) २. राहुं for (राहुं)

३. (वि०—यहां क्रमसंख्या ४८ अंकित है) (च)

(ग) ३. सूर्येः ॥४८॥ for (सूर्यौ)

(वि०—इस श्लोक का उत्तरार्ध ४९ वें श्लोक का पूर्वार्ध है) (च)

(च) १. रक्षस्तद्व्यास for (तत्स्थस्तद्व्यास) ४. क्रमसंख्या लुप्त

(ङ) (वि०—प्रथम पंक्ति समाप्ति पर 'ग्रहण वासना' समाप्ति)

+अथगोलबन्धाधिकारः +आरम्भ ।

२. राहुश्छादयति for (राहुश्छादयति)

परिकरवत्तन्मध्ये भूगोलस्थितद्रष्टुः ।

पूर्वापरयोर्लग्नं याम्योत्तरयोर्नतोन्नतं क्षितिजात् ॥ ४६ ॥

स्वाक्षांशैरुन्मंडलमहर्निशो वृद्धिहानिकरम् ।

विषुवन्मंडलमूढं सममंडलस्थितं स्वकक्षांशैः ॥ ५० ॥

याम्येनोत्तरतोऽधः क्षितिजे प्राच्यपरयोर्लग्नम् ।

विषुवन्मंडललग्नं मेषतुलावावुदकुलीरादौ ॥ ५१ ॥

४६. (घ) १. भूगोलस्तस्थित द्रष्टुः (ङ) for (भूगोलस्थितद्रष्टुः)

(वि०—यहां कोई क्रमसंख्या नहीं दी गई) (च)

(ग) १. स्थितद्रष्टुः ॥४६॥ for (स्थितद्रष्टुः)

२. याम्योत्तरयोर्नतं क्षितिजात् for (याम्योत्तरयोर्नतोन्नतं क्षितिजात्)

(वि०—इस श्लोक का उत्तरार्ध ५० वें श्लोक का पूर्वार्ध है) (च)

(च) १. स्तस्थित for (स्थित) ३. क्रमसंख्या लुप्त ।

५०. (घ) १. रुन्मंडल (ग) for (रुन्मंडल)

२. (वि०—यहां क्रमसंख्या ५० दी हुई है) (ग) (च)

३. मंडलः (ग) मंडलवस्थित for (मंडलस्थित)

४. स्वकक्षांशैः for (स्वकक्षांशैः)

(ग) ५. स्वक्षांशैः for (स्वाक्षांशैः)

(वि०—इस श्लोक का उत्तरार्ध, ५१ वें श्लोक का पूर्वार्ध है) (च)

(च) ३. सममंडलः for (सममंडल) ७. क्रमसंख्या लुप्त

(ङ) ६. महर्निशोर्हानिवृद्धिकरम् for (महर्निशोर्वृद्धिहानिकरम्)

३. सममंडलतः for (सममंडल)

४. स्वकाक्षांशैः for (स्वकक्षांशैः)

५१. (घ) १. (वि०—यहां क्रमसंख्या ५१ दी है) (ग) (च)

(ग) २. याम्यो for (याम्ये) ३. क्षितिज for (क्षितिजे)

४. कुलीरादौ for (कुलीरादौ)

(वि०—इस श्लोक का उत्तरार्ध ५२ वें श्लोक का पूर्वार्ध है) (च)

(च) ४. वृद्धकुलीरादौ for (वृद्धकुलीरादौ) ५. क्रमसंख्या लुप्त ।

(ङ) ३. याम्येनोत्तरतोऽधः for (याम्येनोत्तरतोऽधः)

४. वृद्ध कुलीरादौ for (वृद्धकुलीरादौ)

१. जिनभागेर्याम्येन^१ मृगादावपमंडलमिहार्कः^२ ।
 पातश्चंद्रादीनां^३ भ्रमंति भाद्वे^४ खेश्च भूछाया ॥ ५२ ॥
 पातदयमंडल वल्लि मंडलानि स्वविक्षेपैः^५ ।
 सौम्यं विमंडलार्द्धं^६ प्रथमं याम्यं द्वितीयमेतेषु ॥ ५३ ॥
 चन्द्रकुज जीवमंदा भ्रमंति शीघ्रेण बुधशुक्रौ ।
 दृग्मंडलार्द्धं^७ मूर्द्धं^८ यत्तत्परिधि स्थितं ग्रहं द्रष्टाः ॥ ५४ ॥
 पश्यति यतः क्षितिस्थस्तद्भ्रमति ततो ग्रहाभिमुखं ।
 क्षितिजापमंडलयुतिलंगनं^९ लग्नाग्रतरे^{१०} दिशंवलयनं ॥ ५५ ॥

५२. (घ) १. र्भमोन for (र्याम्येन)

२. (वि० - यहां क्रमसंख्या ५२ दी हुई है) (ग) (च)

३. पाताश्चंद्रादीनां (ग) (ङ) for (पातश्चन्द्रादीनां)

४. भाद्वे for (भाद्वे) (ग) ५. निज for (जिन)

६. भ्रमंते for (भ्रमंति)

(वि०—इस श्लोक का उत्तरार्ध ५३ वें श्लोक का पूर्वार्ध है) (च)

(च) ३. पाताश्चंद्रादीनां for (पातश्चंद्रादीनां) ७. क्रमसंख्या लुप्त

५३. (घ) १. पातादयमंडल (ग) पातादयमंडलवत् for (पातदयमंडलवद्)

२. (वि०—यहां क्रमसंख्या ५३ दी है) (ग) (च)

(ग) ३. विमंडलानि for (द्विमंडलानि)

(वि०—इस श्लोक का उत्तरार्ध ५४ वें श्लोक का पूर्वार्ध है) (च)

४. द्वितीयामातष्ट for (द्वितीयमेतेषु)

(च) १. पातदयमंडल for (पातदयमंडल) ५. क्रमसंख्या लुप्त

(ङ) १. पातादयमंडलवद् for (पातदयमंडलवद्)

५४. (घ) १. (वि०—यहां क्रमसंख्या ५४ दी है) (ग) (च)

२. द्रष्टा (ग) दृष्टा for (द्रष्टाः) (ग) ३. मूर्द्धं for (मूर्द्धे)

(वि०—इस श्लोक का उत्तरार्ध ५५ वें श्लोक का पूर्वार्ध है) (च)

(च) २. द्रष्टा for (दृष्टाः) ४. क्रमसंख्या लुप्त

(ङ) ३. मूर्ध्वं for (मूर्द्धं) २. द्रष्टा for (द्रष्टाः)

५५. (घ) १. (वि०—यहां क्रमसंख्या '५५' दी गई है) (ग) (च)

(ग) २. तद्व्रमति for (तद्भ्रमति) ३. यादिशं for (तोदिशं)

(वि०—इस श्लोक का उत्तरार्ध ५६ वें श्लोक का पूर्वार्ध है) (च)

(च) ४. क्रमसंख्या लुप्त (ङ) ३. लग्नाग्रया for (लग्नाग्रतो)

५. दिशा लग्नम् for (दिशंवलयनं)

हक्षेपं मंडलं दक्षिणोत्तरं वित्रिभ विलग्नम् ॥ ५६ ॥
 विषुवदुदग्बध्नीया क्रत्यांशसमांतरेष्वजादीनाम् ।
 वृत्ततृतीयं व्यस्तं कर्कादीनां तुलादीनाम् ॥ ५७ ॥
 विषुवदक्षिणतो न्यन्मकरादीनां तदेव विपरीतम् ।
 स्वाहोरात्रान्येषां व्यासा पृगवेव भिष्टमपि ॥ ५८ ॥
 लंका समपश्चिमं प्राणेन कलाभूमंडलं भ्रमति ।
 अपमंडलस्य राशिर्द्वादशभागाः क्षितिजलग्नाः ॥ ५९ ॥

५६. (घ) १. तृभ विलग्ने (ग) for (वित्रिभ विलग्नम्)
 (ग) २. हक्षेपमंडलं for (हक्षेपं मंडलं)
 ३. दक्षिणोत्तरं for (दक्षिणोत्तरं)
 (च) २. हक्षेपमंडलं for (हक्षेपं मंडलं)
 ४. विलग्ने for (विलग्नं)
 (ङ) २. हक्षेपमंडलं for (हक्षेपं मंडलं)
 १. वित्रिभ विलग्ने for (वित्रिभ विलग्नम्)
५७. (घ) १. क्रत्यांश (ग) (च) (ङ) for (क्रत्यांश)
 २. कर्कादीनां (ङ) for (कर्कादीनां)
 (ग) ३. विषुवदुदग्बध्नीयात् for (विषुवदुदग्बध्नीया)
 ४. वृत्ततृतीयं (ङ) for (वृत्ततृतीयं)
 (च) २. कर्कादीनां for (कर्कादीनां)
 (ङ) ३. विषुवदुदग्बध्नीयात् for (विषुवदुदग्बध्नीया)
५८. (घ) १. रात्रान्येषां (ग) (च) (ङ) for (रात्रान्येषां)
 २. पृगवेव (ग) (ङ) for (पृगवेव)
 ४. व्यासाः (ङ) for (व्यासा)
 (च) २. पृगवेव for (पृगवेव)
 (ङ) ३. दक्षिणतोऽन्यत् for (दक्षिणतोऽन्यत्)
५९. (घ) १. कलां (ग) (ङ) for (कला)
 २. जलग्नः for (जलग्नाः)
 (ग) ३. भूमंडलं for (भूमंडलं) ४. भाग for (भागाः)
 (ङ) ३. भूमण्डलं for (भूमण्डलं) ४. भागः for (भागाः)

यात्युदयं^१ मेषाद्या यतस्ततस्तदुदयान्कालसमाः ।
 क्रांतिवशालंकायां^४ तदूनताधिक्यमक्षवशात् ॥ ६० ॥
 क्षितिजोन्मंडलयोर्यत्स्वाहोरात्रांतरं^३ चरदलं तत् ।
 क्षितिजेग्राप्राच्यपर स्वाहोरात्रांतरांशज्या ॥ ६१ ॥
 स्वाहोरात्रे क्षितिजाद् दिनगतशेषोच्चतारवेः^२ शंकुः ।
 तस्माद् दिनगतशेषं शंकु कुमध्यांतरं^५ दृग्ज्या ॥ ६२ ॥
 दृग्मंडले नतांशज्या दृग्ज्या शंकुरुन्नतांशज्या ।
 अर्कोदयास्तसूत्रादिनशंकोः^३ दक्षिणे नृतलम् ॥ ६३ ॥
 क्षितिजे भूदललिप्ताः कक्षायां^४ दृग्गतिनभो मध्यात् ।
 अवनति लिप्ता याम्योत्तरारकं ग्रहवदन्यतः ॥ ६४ ॥

६०. (घ) यात्युदयं (ग) यात्युदयं (च) for (यात्युदयं) २. यत for (यत)
 ३. 'न' यहाँ लुप्त है ४. लंकायां (ग) (ङ) for (लंकायां)
 (ग) ५. 'ततस्' पद लुप्त है ६. मन्त्र for (मन्त्र)
 (च) ४. लंकायां for (लंकायां)
 (ङ) १. यात्युदयं for (यात्युदयं) ५. तदुदयां for (ततस्तदुदया)
 ६१. (घ) १. रात्रेतरं for (रात्रांतरं) २. रपस्वाहो for (परस्वाहो)
 (ग) ३. यत for (यत्) (च) १. रात्रेतरं for (रात्रांतरं)
 (ङ) ४. क्षितिजेग्रा for (क्षितिजेग्रा)
 ६२. (ग) १. जातुदिन for (जाह्निक) २. श्च for (श्च)
 ३. ताखे for (तारखे) ४. 'दृग्ज्या' पद लुप्त । यहाँ...कुछ अंश छूटा हुआ है
 (च) ५. तस्मा दिनगत for (तस्माद्दिनगत)
 (ङ) १. क्षितिजाह्निक for (क्षितिजाह्निक)
 ६३. (घ) १. दृग्मंडले (ग) दृग्मंडल for (दृग्मंडले)
 २. शकोर्दक्षिणेन (ङ) (च) for (शंकोःदक्षिणेन)
 (ग) ३. सूत्रान् for (सूत्रादिन) ४. दक्षिणानृतलम् for (दक्षिणेनृतलम्)
 (च) ५. अर्कोदयास्त for (अर्कोदयास्त)
 (ङ) ३. सूत्राह्निक for (सूत्रादिन)
 ६४. (घ) १. स्युरर्कं (ग) रविग्रहवदन्यत् ॥ ६५ ॥ for (रर्कग्रहवदन्यतः)
 (ग) (वि०—इसकी क्रमसंख्या ६५ है) २. 'भू' लुप्त है ३. दृक्नति for (दृग्गति)
 (च) ३. दृग्गतिन्नभोमध्यात् for (दृग्गतिन्नभोमध्यात्)
 (ङ) ३. दृक्नतिर् for (दृग्गति) १. रवि for (रर्क) ४. वदन्यत्र for (वदन्यतः)

दृश्यादृश्यं दृग्गोलाद्धं भूव्यासदलविहीनयुतम् ।
 दृष्टाभूगोलोपरि यतस्ततो लंबनावनति ॥ ६५ ॥
 सत्रिग्रह क्रांतिरूदग्दक्षिणयोस्त्रिज्यया हतं चलनम् ।
 विक्षेपगुणमृणधनं ग्रहेन्यदृक्कर्म चरदलवत् ॥ ६६ ॥
 कक्षामंडलतुल्यं प्राच्यपरं दक्षिणोत्तरं क्षितिजम् ।
 उन्मंडलविषुवन्मंडले स्थिराणि ग्रहर्क्षाणाम् ॥ ६७ ॥
 मंदोच्याना सप्तोच्चनीच वृत्तानि पंचशीघ्राणाम् ।
 प्रतिमंडलानि चैवं प्रत्येकां भास्करादीनाम् ॥ ६८ ॥
 दग्मंडलदक्षेपापमंडलानि क्षपाकरादीनाम् ।
 षट्कं विमण्डलान्यं चलवृत्त्यानेक पंचाशत् ॥ ६९ ॥

६५. (घ) १. दृश्यो for (दृश्यादृश्यं)

(ग) (वि०—इसकी क्रमसंख्या ६४ है)

२. गोलाद्धं for (दृग्गोलाद्धं) ३. विहीनम् for (विहीन)

४. दृष्टो for (दृष्टा) (वि०—दूसरी पंक्ति 'भूगोल' से आरम्भ है)

५. 'दृष्टा' लुप्त है ६. नती ॥६४॥ for (नति ॥६५॥)

(च) २. दृग्गोलाद्धं for (दृग्गोलाद्धं)

(ङ) (वि०—यह श्लोक उपलब्ध नहीं)

६६. (घ) १. ग्रह (च) (ङ) for (ग्रह) २. हतं (च) (ङ) for (हतं)

३. ग्रहे (च) for (ग्रहे) ४. न्यदृक्कर्म (ग) (ङ) for (न्यदृक्कर्म)

(ग) ५. रुदक् for (रूदग्) ६. गुणधनं for (गुणमृणधनं)

६७. (ग) १. कक्ष्या for (कक्षा) २. प्राच्यरं for (प्राच्यपरं)

३. क्षिजम् for (क्षितिजं)

६८. (घ) १. मंदोच्यानां (ग) (च) (ङ) for (मंदोच्याना)

(ग) २. प्रत्येकं (च) for (प्रत्येकां)

६९. (घ) १. दृक्षेपाप (ग) विक्षेपाप (ङ) for (दक्षेपाप)

२. विमंडलानां (ग) (ङ) for (विमंडलान्यं)

३. वृत्तान्येक (ग) चलवृत्तान्येक for (चलवृत्त्यानेक)

४. पंचाशतः for (पंचाशत्)

(ग) ५. दृग्मंडल (ङ) for (दग्मंडल)

६. क्षिपा for (क्षपा)

(च) १. विक्षेपाप for (दक्षेपाप) २. विमंडलानां for (विमंडलान्यं)

यत्स्पष्टीकरणाद्यं गोलादुत्क्षेपतत्कृतं सर्वं गोलाध्यायः ।

सप्तत्यार्याणामेकं विशोयम् ॥ ७० ॥

मध्याद्यमिह यदुक्तं तत्प्रत्यक्षमिव दर्शयति यस्मात् ।

तस्मादाचार्यत्वं गोलविदो भवति नान्यस्य ॥ ७१ ॥

आचार्येण ज्ञातः श्रीषेणार्यभटविष्णुचंद्राद्यैः ।

गोले यस्मात्तस्माद् ब्राह्मे गोलः कृतः स्पष्टः ॥ ७२ ॥

गणितज्ञो गोलज्ञो गोलज्ञो ग्रहगतिं विजानाति ।

यो गणितगोलबाह्यो जानाति ग्रहगतिं सः कथम् ॥ ७३ ॥

इति ब्रह्मगुप्ते गोलाध्यायः (२१ अध्यायः समाप्तः)

एकं विशतितमः समाप्तः

७०. (घ) १. दुत्प्रक्षेप (ग) दुत्प्रक्षेप्य (ङ) for (दुत्क्षेप)

२. (वि०—यह दूसरी पंक्ति का आरम्भिक शब्द है) (ग) (ङ)

(ग) ३. सर्वा for (सर्व) ४. समाप्ति सूचक ॥ छः॥ ॥छः॥ ॥छः॥

(च) १. दुत्प्रक्षेपतत्कृतं for (दुत्क्षेपतत्कृतं)

(ङ) +इति श्री ब्राह्मस्फुट सिद्धान्ते गोलाध्यायो नामैकविंशतितमोऽध्यायः+

(वि०—वस्तुतः गोलाध्याय यहाँ ७० वें श्लोक पर समाप्त हो गया है।

परन्तु उपर्युक्त प्रति में यन्त्राध्याय के पहले तीन श्लोक मिलाकर ७३ पर समाप्त किया है)

७१. (घ) १. गोलो भवति for (गोलविदो भवति) (वि०—इसकी क्रमसंख्या १ है)

(ङ) वि०—यह 'यन्त्राध्याय' का प्रथम श्लोक है)

७२. (घ) १. आचार्येण (ङ) for (आचार्येण) (ग) २. ज्ञाता for (ज्ञातः)

३. 'विष्णु' पद लुप्त है। ४. गोलो (ङ) (च) for (गोले)

५. ब्राह्मे (ङ) for (ब्राह्मे) (वि०—इसकी क्रमसंख्या २ है)

१. आचार्येण for (आचार्येण) (ङ) (वि०—यह यन्त्राध्याय का द्वितीय श्लोक है)

७३. (घ) १. इति भट्ट जिष्णुसुतब्रह्मगुप्त विरचिते ब्रह्मस्फुट सिद्धान्ते गोलाध्यायः एक विशतितमः । for (इति ब्रह्मगुप्ते गोलाध्यायः)

(ग) २. ग्रहति for (ग्रहगति) ३. स (ङ) (च) for (सः)

१. ये पद लुप्त है (वि०—इसकी क्रमसंख्या ३ है)

(च) १. इति भट्ट जिष्णुसुत ब्रह्मगुप्त विरचिते ब्राह्मे स्फुटसिद्धान्ते गोलाध्यायः एक विशतितमः for (इति ब्रह्मगुप्ते गोलाध्यायः २१ अध्यायः समाप्तः)

(ङ) (वि०—यह यन्त्राध्यायः का तीसरा श्लोक है)

अथ यन्त्राध्यायो नाम

द्वाविंशः

कालस्य परिछेदः कर्तुं यन्त्रं विना यतो शक्यः ।
 संक्षिप्तं स्पष्टार्थं यन्त्राध्यायं ततो वक्ष्ये ॥ १ ॥
 सप्तदशकालयन्त्राण्यतो धनुस्तुर्यगोलकश्चक्रम् ।
 यष्टिशंकुर्घटिका कपालकं कर्त्तरिकोटम् ॥ २ ॥
 सलिलभ्रमोवलंबः कर्णछाया दिनार्द्धमर्कोक्षः ।
 नवकाल ज्ञानार्थं तेषां संसाधानान्यष्टौ ॥ ३ ॥

१. (घ) १. विना (ग) (च) (ङ) for (विना)
 (ग) २. गोलस्य (ङ) for (कालस्य)
 ३. यतोऽशक्यः (ङ) for (यतोऽशक्यः)
 (वि०—इसकी श्लोक संख्या ४ है)
 (ङ) (वि०—श्लोक संख्या ४ है इसके पूर्ववर्ती तीन श्लोकों को गोलाध्याय के अंत में रख दिया गया है)
 ४. परिछेदः for (परिछेद)
२. (घ) १. घटिका for (घटिका) २. कर्त्तरी (ग) (च) (ङ) for (कर्त्तरि)
 ३. फीटं (ग) पीठम् for (कीटम्)
 (ग) ४. गोलकं चक्रम् for (गोलतश्चक्रम्)
 ५. यष्टिः (च) (ङ) for (यष्टि)
 (वि०—इसकी श्लोक संख्या ५ है)
 (च) ३. फीटा for (कीटम्)
 (ङ) ३. पीठम् for (कीटम्)
३. (ग) १. सलिलं (ङ) for (सलिल) २. ब्रमो for (भ्रमो)
 ३. कर्णछाया (ङ) for (कर्णछाया) ४. नय for (नव)
 ५. यहां अनुस्वारलुप्त है ।
 (वि०—इसकी श्लोक संख्या ६ है)
 (च) २. ज्वलंबः for (वलंबः) ६. मर्कोक्षः for (मर्कोक्षः)
 (ङ) २. भ्रमोज्वलम्बः for (भ्रमोवलंबः)
 ६. मर्कोक्षः for (मर्कोक्षः) ४. नत for (नव)

सलिले न समं साध्यं भ्रामणवृत्तमवलंबं केनोद्धम् ।
 तिर्यक् कर्णोनान्यैः कथितैश्च नव प्रसाध्यति ॥ ४ ॥
 धार्यं धनुस्तथाग्रछायासाम्यं यथोन्नता भागाः ।
 दिनगतशेषा घटिकाश्चलंबमुक्ता धनुर्मध्यात् ॥ ५ ॥
 धार्यं समं तथा वा ज्या छाया पृथगा यथा भवति अग्रादम् ।
 शक घटिका ज्यामध्यछायया मुक्ता ॥ ६ ॥
 घटिका स्वशंकुभागैः पृष्ठगतै लंबं भूसमं समज्याद्धात् ।
 सशिति शतांशकं चक्रास्याद्धं धनुर्यत्रम् ॥ ७ ॥

४. (घ) १. भ्रमेण (ग) (ङ) for (भ्रामण)
 २. तिर्यक्कर्णोनान्यैः (ग) (ङ) तिर्यक्कर्णोनान्यैः for (तिर्यक्कर्णोनान्यैः)
 ३. प्रसाध्यानि (ग) प्रवक्ष्यामि for (प्रसाध्यति)
 (ग) ४. केनोद्धम् (ङ) for (केनोद्धम्) ५. तिर्यक् (ङ) for (तिर्यक्)
 (वि०—इसकी श्लोक संख्या ७ है)
 (च) ५. तिर्यक्कर्णोनान्यैः for (तिर्यक्कर्णोनान्यैः)
 ३. प्रसाध्यानि for (प्रसाध्यति) (ङ) ३. प्रवक्ष्यामि for (प्रसाध्यति)
 ५. (ग) १. तथान्य for (तथाग्र) (वि०—इसकी श्लोक संख्या ८ है)
 २. भागम् for (भागाः) ३. धनुर्मुक्तान् for (धनुर्मध्यात्)
 (ङ) १. तथाऽन्यत् for (तथाग्र) ४. स्वलम्बमुक्ता for (श्चलंबमुक्ता)
 ६. (घ) १. पृथगा (ग) for (पृथगा) २. (वि०—दूसरी पंक्ति का आरम्भिक पद) (ग)
 ३. छायाया (ग) छाया यथा for (छायया) (ग) ४. धार्यं (ङ) for (धार्यं)
 २. अग्रादश for (अग्रादम्) ५. मुक्ताः ॥६॥ (ङ) for (मुक्ता)
 (वि०—इसकी श्लोक संख्या ६ है) (च) ३. छायाया for (छायया)
 (ङ) १. मध्यगा for (पृथगा) २. अग्रादिष्टा for (अग्रादम्) ६. 'शक' लुप्त
 ७. (घ) १. सशीति (ग) साशीति (ङ) for (सशिति)
 २. शतांशकं (ग) शाकं (ङ) for (शतांशकं)
 ३. चक्रास्याद्धं (ग) for (चक्रास्याद्धं) (ग) ४. घटिकाः (च) for (घटिका)
 ५. लंबं (ङ) for (लंबं) ६. 'समं' पद लुप्त है ।
 (वि० इसकी श्लोकसंख्या १० है)
 (च) १. सशीति for (सशिति) २. शतांशकं for (शतांशकं)
 ३. चक्रास्याद्धं for (चक्रास्याद्धं) (ङ) ७. पृथगतै for (पृष्ठगतै)
 ६. भू for (भूसमं)

मध्यादिनोन्नतांशं विनाद्धं नाड्यो वदन्ति तुल्या ये ।
 ते सूर्यास्त छादष्ट छाया समान यतः ॥ ८ ॥
 जीवा स्वाहोरात्रं परिकल्पाग्रा नतोन्नतत्रिज्या ।
 अनुपातात् तत्कार्या सूर्यगोलके चक्रं चैवम् ॥ ९ ॥
 दिन घटिकांकितपृष्ठे व्यस्त न तज्याग्रोन्नतज्या ।
 चदिग्मध्ये च शलाकातछायाग्रं न तानाड्यः ॥ १० ॥

८. (घ) १. दृष्ट (ग) छायादृष्ट for (छादष्ट) २. समानयत for (समानयतः)
 (ग) ३. मध्यदिनोन्नतांशं for (मध्यादिनोन्नतांशं)
 ४. नाडी for (नाड्यो) ५. तुल्यायै for (तुल्याये)
 ६. सूर्यास्त for (सूर्यास्त) (वि०—इसकी श्लोक संख्या ११ है)
 (च) १. छादष्ट for (छादष्ट) २. युतः for (यतः)
 (ङ) ३. मध्यदिवसोन्नतांशं for (मध्यादिनोन्नतांशं)
 ४. नाडीवदन्ति for (नाड्योवदन्ति) ६. ते सूर्यास् for (ते सूर्यास्)
 १. तच्छाया इष्ट for (तच्छादष्ट)
 ९. (घ) १. नतो (ग) नतोन्नत for (नतोन्नत) २. स्तुर्या (ग) स्तुर्य for (सूर्य)
 ३. चक्रके (ङ) for (चक्रे)
 (ग) ४. प्रकल्प्यग्रा for (परिकल्पाग्रा)
 ५. अनुपातात्कार्या for (अनुपातात्तत्कार्या)
 (वि०—इसकी श्लोक संख्या १२ है)
 (च) १. नतोन्नतत्रिज्या for (नतोन्नतत्रिज्या) २. स्तुर्यगोलके for (सूर्यगोलके)
 (ङ) ६. जीवा स्वाहोरात्रे for (जीवास्वाहोरात्रं)
 ४. (परिकल्पाग्रा) for (परिकल्पाग्रा)
 १. नतोन्नतत्रिज्याः for (नतोन्नतत्रिज्या)
 २. कार्यास्तुर्यगोलके for (कार्यास्तुर्यगोलके)
 १०. (घ) १. (च) (वि०—पहली पंक्ति का अंतिम पद) (ङ)
 २. 'दिग्मध्ये' से आरम्भ (ग) दिनमध्ये for (दिग्मध्ये)
 (ग) ३. पृष्टि for (पृष्ठे) ४. व्यस्तनज्याग्र for (व्यस्तनतज्याग्रो)
 ५. उन्नतज्या च for (ग्रोन्नतज्या) ६. शलाका for (शलाका)
 ७. अन्नता नाड्यः for (अन्नतानाड्यः)
 (वि०—इसकी श्लोक संख्या १३ है)
 (ङ) ३. पृष्ठे for (पृष्ठे)
 ४. अनुन्नतज्या for (ग्रोन्नतज्या) ७. तच्छायाग्रान्नता for (तच्छायाग्रान्नता)

पृष्ठो नेष्टो वेध्यो ज्यामध्यसंस्थाया ।

द्रष्ट्या द्रष्टांतरं न तज्या धनुषि द्वायोन्नत ज्याया ॥ ११ ॥

ज्याद्धं द्रष्टुं द्रज्यान्नत जीवा शंकुमुन्नतज्या च ।

धनुषि प्रकल्पयोज्यां यष्ट्युक्तं नाडिकाद्येता ॥ १२ ॥

अवलंबनं शलाकां ज्याद्धं यष्टि प्रकल्पवा धनुषि ।

भूम्युच्चायं बहुशो यष्ट्युक्तं रानयेत्कर्णः ॥ १३ ॥

११. (घ) १. धनुषपृष्ठेनेष्टौ वेध्यो (ग) धनुष पृष्ठेनेष्टौवेध्यो for (पृष्ठेनेष्टौ वेध्यो)
 २. संस्थया (ग) (च) (ङ) for (संस्थाया)
 ३. द्रष्ट्या (ग) द्रष्ट्या (ङ) for (द्रष्ट्या) (वि—पहलौ पंक्ति का अंतिम पद)
 ४. द्रष्टांतरं (ग) (ङ) for (द्रष्टांतरं) ५. ज्यायाः (ङ) for (ज्याया)

(ग) (वि०—इसकी क्रमसंख्या १४ है)

- (च) १. धनुषपृष्ठे for (पृष्ठे) ३. द्रष्ट्या for (द्रष्ट्या)
 ६. तज्या for (तज्या) ५. ज्यायाः for (ज्याया)
 (ङ) १. धनुषः पृष्ठे द्रष्ट्या for (पृष्ठे नेष्टो) ७. वेध्या for (वेध्यो)
 ३. ४. द्रष्टांतरं for (द्रष्ट्या द्रष्टांतरं) ३. द्रष्ट्या for (द्रष्ट्या)

१२. (घ) १. द्रष्टिं (ग) यष्टि for (द्रष्टि) २. द्रज्या (ग) द्रज्यां (ङ) for (द्रज्या)
 ३. नाडिकाद्यन्ता (ग) नाडिकाद्यं च for (नाडिकाद्यन्ता)
 (ग) ४. ज्याद्धं (ङ) for (ज्याद्धं) ५. नतजीवां for (नतजीवा)
 ६. ज्यां च for (ज्याच) ७. प्रकल्प्य for (प्रकल्प)
 ८. योज्यं for (योज्यां) (वि०—इसकी श्लोकसंख्या १५ है)

- (च) १. द्रष्टि for (द्रष्टि) २. द्रज्या for (द्रज्या)
 ५. नतजीवां for (नतजीवा) ६. ज्याव for (ज्याच)
 (ङ) १. द्रष्टे for (द्रष्टि) ६. यष्ट्युक्तं for (यष्ट्युक्तं)

१३. (घ) १. ज्याद्धं for (ज्याद्धं)
 २. भूम्युच्चायं (ग) भूम्युच्चाया for (भूम्युच्चायं)
 (ग) २. अवलंबनं for (अवलंबनं) ४. प्रकल्प्य (ङ) for (प्रकल्प)
 ५. बाहुःशो for (बहुशो) ६. यष्ट्युक्तं for (यष्ट्युक्तं)
 (वि०—इसकी श्लोक संख्या १६ है)
 (च) २. भूम्युच्चायं for (भूम्युच्चायं) ७. कर्णः (ङ) for (कर्णः)
 (ङ) २. भूम्युच्चाया for (भूम्युच्चायं) ५. श्लम्बो for (बहुशो)

यष्टि^२ व्यासा^४र्द्धं तु विवृत्तं^५ भगणां^१शांकितं^३ कृत्वा ।
 यष्टिकीलप्रोते मूले^२ पृथग्भग्नयो^५ विद्धे^३ ॥ २१ ॥
 ताम्यां^१ सूर्यशशांको^२ वेध्यावर्गस्थितेन^५ सूत्रेण ।
 सूत्रज्यायांतरां^२ शायेतेऽर्कं^५ विभाजिता^३ स्थितयः ॥ २२ ॥
 सूत्रार्द्धगुणा^५ त्रिज्या यष्टिहता^३ फलधनुद्विगुणितं^५ वा ।
 रविचंद्रांतरमिष्टव्यासा^५र्द्धोल्लितवृत्तस्य ॥ २३ ॥
 मध्यधृतायायष्टे^५ लंबकशंकुप्रवेशनिर्गमने ।
 क्रांतिवशात्प्राच्यपरे^५ मत्साद्याम्योत्तरे^३ साध्ये ॥ २४ ॥

२१. (घ) १. भगणांशकांकितं (ग) (च) for (भगणांशांकितं)
 २. यष्टी (ग) (ङ) (च) for (यष्टि)
 ३. विद्धे (ग) विधिः (विधेः) for (विद्धे)
 (ग) ४. व्यासा^४र्द्धा^५र्द्धं वि (ङ) for (व्यासा^४र्द्धा^५र्द्धं वि)
 ५. मूल for (मूले) ६. प्रथग्नयो (च) for (पृथग्भग्नयो)
 (वि०—इसकी श्लोकसंख्या २४ है)
 (च) ४. भुविवृत्तं for (तुविवृत्तं)
 ७. कृत्वा for (कृत्वा) ३. विद्धे for (विद्धे)
 (ङ) १. भगणांशकं for (भगणांशांकितं) ६. पृथग्नयो for (पृथग्भग्नयो)
 ३. बंधे for (विद्धे)
२२. (घ) १. वाम्यां for (ताम्यां)
 २. ज्यायांतरांशा (ग) (च) (ङ) for (सूत्रज्यायांतरांशा)
 ३. स्थितयः (ग) (च) (ङ) for (स्थितयः)
 (ग) ४. वर्ग (च) (ङ) for (वर्ग) ५. येतेऽर्कं for (येतेऽर्कं)
 (वि०—इसकी श्लोकसंख्या २५ है)
 (च) ५. येतेऽर्कं for (येतेऽर्कं)
२३. (ङ) १. हता (ग) (ङ) (च) for (हता)
 २. द्विगुणितं (ग) (ङ) (च) for (द्विगुणितं)
 ३. व्यासा^४र्द्धोल्लिखित (ग) (ङ) (च) for (व्यासा^४र्द्धोल्लित)
 (ग) ४. रविचंद्रांतर (च) for (रविचंद्रांतर) (वि०—इसकी श्लोकसंख्या २६ है)
२४. (घ) १. मत्साद्याम्योत्तरे (ङ) (ग) मत्साद्याम्योत्तरे for (मत्साद्याम्योत्तरे)
 (ग) २. (वि०—इसकी श्लोकसंख्या २७ है)
 (च) १. मत्साद्याम्योत्तरे for (मत्साद्याम्योत्तरे)

शंकुतलानांतरयुतिरन्यैकदिशोभुजो भुजस्य कृतिम् ।
 दृग्ज्या कर्णकृतेः प्रोह्यपदपूर्वापरा कोटिः ॥ २५ ॥
 उदयास्तसूत्रशंक्वंतरं हृतं शंकुनाकंसंगुणितम् ।
 विषुवच्छायैवं वा दिनोदयास्तमयसूत्रेण ॥ २६ ॥
 प्राच्यपरा शंकुतलानंतरयुति समान्यदिशो ।
 द्वादशगुणिता विषुवच्छाया शंक्वंतरविभक्ता ॥ २७ ॥

२५. (घ) १. शंकुतलाग्रांतर (ङ) (ग) शंकुतलग्नानंतर for (शंकुतलानांतर)
 २. दिशा (ग) दिशोभुजो (ङ) for (दिशोभुजो)
 ३. कृतिः (ग) कृतेः (ङ) for (कृतेः) ४. पदं (ग) प्रोह्यपदं for (पद)

(ग) ५. कोटि for (कोटिः)

(वि०—इसकी श्लोकसंख्या २८ है)

- (च) १. शंकुतलग्नानंतर for (शंकुतलानांतर) २. दिशौ for (दिशो)
 ३. कृतेः for (कृतेः) ४. प्रोह्यपद for (प्रोह्यपद)

(ङ) ४. पदं for (पद)

२६. (घ) १. शंक्वंतरहृतं (ग) हृतं for (हृतं)
 २. नाकं १२ संगुणितम् (ग) शंकुनाकं संगुणितम् for (शंकुनाकंसंगुणितम्)
 ३. छायायैवं (ग) विषुवच्छायेव वा for (विषुवच्छायैवं)

(ग) (वि०—इसकी श्लोक संख्या २९ है)

४. दिनोदयास्तमयसूत्रेण (ङ) for (दिनोदयास्तमयसूत्रेण)

(च) १. हृतं for (हृतं)

२. शंकुनाकं १२ for (शंकुनाकं)

३. विषुवच्छायैवं for (विषुवच्छायेव वा)

(ङ) ३. विषुवच्छायैवं for (विषुवच्छायैवं)

२७. (घ) १. युतिः (च) (ङ) for युति)
 २. दिशोः (च) (ङ) for (दिशो)
 ३. विभक्ताः for (विभक्ता)

(ग) (वि०—इसकी श्लोक संख्या ३० है)

४. द्वांतरयुति (ङ) for (युति)

५. द्वादशविभक्ता for (द्वादश) ६. 'गुणिता' पद लुप्त है ।

शंकुप्राच्यपरांतरं शंकुवग्रं कथमुदयांतरं याम्ये ।
 लब्धगुणं यष्टिगुणं क्रांति ज्यातो रविः प्राग्वत् ॥ २८ ॥
 अपसृतिरन्यशलाका गुणाशलाकधांतरेण भक्ता भूः ।
 भू स्वशलाका गुणिता गुणिताद्रष्टि विभक्ता ॥ २९ ॥

२८. (घ) १. हृतं (ग) for (गुणं)
 (ग) २. प्राच्या for (प्राच्य) (वि०—इसकी श्लोक संख्या ३१ है)
 ३. मुदगंतरं यामे for (मुदयांतरं याम्ये)
 (च) १. हृतं (ङ) for (गुणं)
 (ङ) ३. मुदगंतरं for (मुदयांतरं)
 ४. लब्धगुणं for (लब्धगुणं)
२९. (घ) १. शलाकधांतरेण (ग) शलाकांतरेण (ङ) for (शलाकधांतरेण)
 २. 'गुणिता' लुप्त
 ३. द्रष्टि (ग) द्रिष्टि for (द्रष्टि)
 (वि०—इसकी क्रमसंख्या ३० है)
 (ङ) ६. भूः for (भू)
 ३. ४. यष्टि विभक्ता गृहाद्यौच्यम् for (गुणिता द्रष्टि विभक्ता)
 (ग) (वि०—इसकी श्लोकसंख्या ३२ है)
 ४. 'गृहाद्यौच्यम्' पंक्ति का अंतिम शब्द । ३. द्रष्टि for (द्रष्टि)
 ५. (वि०—इसकी क्रमसंख्या ३० अंकित है)
 ४. + 'गृहाद्यौच्यं' यह पद पृष्ठ के नीचे अन्य हाथ से लिखा हुआ है ।
 द्रष्ट्या गुणितापसृति द्रष्टि विशेषभाजिता भूमिः ।
 भूमिस्व द्रिष्टिभक्ता शलाकाया संगुणोत्थायम् ॥ ३३ ॥
- (च) यह अतिरिक्त श्लोक यहां पृष्ठ के निम्नोपांत पर अन्यहस्तसे लिखा हुआ है ।
 १. द्रष्टि for (द्रष्टि) २. भूः for (भूमिः)
 ३. द्रष्टि for (द्रिष्टि)
 ४. शलाकया (ङ) for (शलाकाया)
 ५. संगुणोत्थाय (ङ) for (संगुणोत्थायम्)
 (वि०—इसकी भी क्रमसंख्या ३० अंकित है)
- (ङ) १. द्रष्टि विशेषेण for (द्रष्टिविशेष) ७. भूमिः for (भूमि)
 ३. द्रष्टि for (द्रिष्टि)

लंबनिपातांतरकं लंबौच्यांतरविभक्तमधिकगुणम् ।

भूर्लंबांतरगुणिता लंबनिपातांतरविभक्ता ॥ ३० ॥

लब्धोनाद्रक् लम्बोदग्लम्बा दग्रलंबके हीने ।

अधिकेऽधिको ग्रहोच्यं तलाग्रवेध द्वया षष्ट्या ॥ ३१ ॥

दृष्टिर्द्रक् लंबगुणा विभाजिताद्यः शलाकया भूमिः ।

सकलशलाका गुणिता भूमिदृष्ट्या हतोद्धायः ॥ ३२ ॥

३०. (घ) १. भूर्लंबांतर for (भूर्लंबांतर)

२. लंबनिपातांतर for (लंबनिपातांतरकं)

३. विभक्ताः for (विभक्ता)

(वि०—इसकी क्रमसंख्या ३१ है)

(ग) (वि०—इसकी श्लोकसंख्या ३४ है)

(च) १. भूर्लंबांतर for (भूर्लंबांतर)

४. (वि०—यहां क्रमसंख्या ३१ अंकित है)

३१. (घ) १. लब्धोनाद्रक् (ग) सधेनो द्रिग् for (लब्धोनाद्रक्)

२. लंबोदग्लंबा (ग) (च) (ङ) for (लंबोदग्लंबा)

३. गृहोच्यं (ग) (च) (ङ) for (ग्रहोच्यं)

४. तलाग्रवेध (ग) तलाग्रवे बध्यया for (तलाग्रवेध)

५. द्वया यष्ट्या (ग) द्रिष्ट्या ॥ ३५ ॥ for (द्वयाषष्ट्या)

(वि०—इसकी क्रमसंख्या ३२ है)

(ग) (वि०—इसकी श्लोक संख्या ३५ है)

(च) १. नाद्रक् for (नाद्रक्) ५. द्वया यष्ट्या for (द्वया षष्ट्या)

६. (वि०—क्रमसंख्या ३२ अंकित है)

(ङ) १. लब्धोनाद्रक् for (लब्धोनाद्रक्) ४. तलाग्रके for (तलाग्र)

५. विद्वया दृष्ट्या for (वेधद्वयाषष्ट्या)

३२. (घ) (वि०—इसकी क्रमसंख्या ३३ है)

१. यष्टियैलग्नंबगुणा (ग) दृष्टिर्द्रक्लंबगुणा for (दृष्टिर्द्रक्लंबगुणा)

२. विभाजिताद्यः (ग) (च) (ङ) for (विभाजिताद्यः)

३. गुणिताः (च) for (गुणिता) ४. भूमिर्दृष्ट्या (ङ) for (भूमिदृष्ट्या)

५. हतोद्धायः (ग) (च) (ङ) for (हतोद्धायः)

(ग) (वि०—इसकी श्लोकसंख्या ३६ है)

(च) १. दृष्टिर्द्रक् for (दृष्टिर्द्रक्) ६. (वि०—यहां क्रमसंख्या ३३ अंकित है)

(ङ) १. दृष्टिर्द्रक्लम्ब for (दृष्टिर्द्रक्लम्ब)

मित्राग्रहैकदेशे^१ विद्वेष्ट^७ शलाकया^३ न्ययासर्वम्^५ ।
 प्रथमशलाकाभक्तं^२ मीतं^४ द्वितीया^६ गुणितमौच्यम्^८ ॥ ३३ ॥
 षष्ट्याहूता^१ शलाका^३ त्रिज्याघात^२ धनु^४ गृहान्तरकं^५ ।
 यैरुक्तं^६ सूखास्ते यतो न द्रष्टव्यन्तरं^७ द्रज्या ॥ ३४ ॥
 मूलेद्व^१ गुलविपुलः^२ शुच्यग्रो^३ द्वादशांगुलोद्भायः^४ ।
 शंकुतलाग्रविद्धो^५ प्रवेध^६ लम्बाद्भायः^७ ॥ ३५ ॥

३३. (घ) १. गृहैक (ग) (च) (ङ) for (ग्रहैक) (वि०—इसकी क्रमसंख्या ३४ है)
 २. शलाका (ग) शिलाका for (शलाका)
 ३. मिति (ग) मितं (ङ) for (मीत) ४. द्वितीयया for (द्वितीया)
 ५. गुणिताम्यौच्यम् for (गुणितमौच्यम्)
 (ग) ६. देशं (च) for (देशे) ७. विधेष्ट for (विद्वेष्ट)
 ८. गृहम् for (न्यया) (वि०—इसकी श्लोकसंख्या ३७ है)
 (च) ३. मित for (मीत) ४. द्वितिया for (द्वितीया)
 ५. गुणितम्यौच्यं for (गुणितमौच्यं) (ङ) ७. विद्वेष्ट for (विद्वेष्ट)
 ३४. (घ) १. यष्ट्याहूता (ग) त्रिज्याहूत for (षष्ट्याहूता)
 २. घाता (ग) for (घात) ३. गृहान्तरकम् (च) for (गृहान्तरकम्)
 ४. यैरुक्तं (च) for (यैरुक्तं) ५. दृष्टव्यन्तरं (ग) (च) for (द्रष्टव्यन्तरं)
 ६. द्रज्या (ग) द्रज्याजुर्द्भायः ॥ ३८ ॥ for (द्रज्या)
 (च) १. यष्ट्याहूता for (षष्ट्याहूता) ६. द्रज्या for (द्रज्या)
 ७. (वि०—क्रमसंख्या ३५ अंकित है) (घ)
 (ङ) १. यष्ट्याहूताच्छलाका for (षष्ट्याहूताशलाका)
 २. घाताद्धनुर्गृहान्तरकम् for (घातधनुर्गृहान्तरकम्)
 ५. दृष्टान्तरम् for (द्रष्टव्यन्तरं) ७. द्रज्या for (द्रज्या)
 ३५. (घ) १. द्विगुल (ग) द्वयंगुल (ङ) for (द्विगुल) (वि०—इसकी क्रमसंख्या ३६ है)
 २. शुच्यग्रोः (ग) शुच्यग्रो for (शुच्यग्रो)
 ३. शंकुतलाग्र (ग) for (शंकुतलाग्र) ४. द्वादृर्भायः for (द्वादयः)
 (ग) ५. विपुल for (विपुलः) ६. विधोप्रवेध for (विद्धोप्रवेध)
 ७. लम्बाद्भायः ॥ ३९ ॥ for (लम्बाद्भायः)
 (वि०—इसकी श्लोक संख्या ३९ है)
 (च) २. शुच्यग्रोः for (शुच्यग्रो) ८. द्वादयः for (द्वादयः)
 ७. लम्बाद्भायः (लम्बाद्भायः) (वि०—क्रमसंख्या ३६ अंकित है)
 (ङ) २. शुच्यग्रो for (शुच्यग्रो) ६. विद्धा for (विद्धो) ४. भृदुद्भायोः for (द्वादयः)

छाया^४हृज्या^५ यष्टि^१ छाया^१कर्णं मवलम्बकम् शंकुं ।
 परिकल्पां^२ शंकुं यंत्रे^३ योज्यं घटिकादिषु^३ष्ट्युक्तम् ॥ ३६ ॥
 घटिकाकलशाद्धै^४कृतिताम्रं पात्रं तले गुरु^३च्छिद्रम् ।
 मध्येतज्जलमज्जनं^५ षष्ट्या^१ द्युनिशं यथा भवति ॥ ३७ ॥
 मध्याध्यस्तनतांशैः^१ कपालकं दिक्स्थ^२ सूत्रात् मग्रात् ।
 व्यस्तोन्नतांशा विवरे^५ सूत्रं^५ कथा पाततो नाड्यः ॥ ३८ ॥

३६. (घ) (वि०—इसकी क्रम संख्या ३७ है)

१. छायाकर्णं (ग) (च) (ङ) for (छायाकर्णं)

२. परिकल्प्या (ग) परिकल्प्य (ङ) for (परिकल्प्यां)

३. घटिकादि पुष्ट्युक्तम् (ग) घटिकादि यष्ट्युक्तम् for (घटिकादि पुष्ट्युक्तम्)

(ग) ४. हृज्यां (ङ) for (हृज्या) (वि०—इसकी श्लोकसंख्या ४० है)

(च) २. परिकल्प्य शंकु for (परिकल्प्यांशंकु)

३. घटिकादिसंयुक्तम् for (घटिकादिषु ष्ट्युक्तम्)

(वि०—क्रमसंख्या ३७ अंकित है) (ङ) ५. दृष्टि for (यष्टि)

३७. (घ) (वि०—इसकी क्रमसंख्या ३८ है)

१. कलशाद्धाकृति (ग) कलशाद्धा for (कलशाद्धै)

(ग) २. कृतिताम्रं for (कृतिताम्रं) ३. पृथु for (गुरु)

४. मज्जन for (मज्जनं) (वि०—इसकी श्लोकसंख्या ४१ है)

(च) २. कृतिताम्रं (ङ) for (कृतिताम्रं)

(वि०—इसकी क्रमसंख्या ३८ अंकित है) (ङ) कलशाद्धा for (कलशाद्धै)

३. ष्ट्युच्छिद्रम् for (गुरुच्छिद्रम्)

३८. (घ) (वि०—इसकी क्रमसंख्या ३९ है)

१. द्व्यस्त (ग) मध्यद्व्यस्तनतांशै for (मध्यव्यस्तनतांशैः)

२. दिक्स्थ (ग) दिक्स्थ (ङ) for (दिवक्स्थ)

३. सूत्रमग्रात् (ग) सूत्रमग्रात् for (सूत्रात्मग्रात्)

(ग) (वि०—इसकी श्लोकसंख्या ४२ है)

४. व्यस्तोन्नत्वंश for (व्यस्तोन्नतांशा) (च) १. द्व्यस्त for (द्व्यस्त)

२. दिक्स्थ for (दिवक्स्थ) ३. सूत्रमग्रात् for (सूत्रात्मग्रात्)

४. व्यस्तोन्नतांश for (व्यस्तोन्नतांशा) ५. विवरे for (विवरे)

६. (वि०—क्रमसंख्या ३९ for (३८))

(ङ) १. मध्याध्यस्तनतांशैः for (मध्याध्यस्तनतांशैः)

३. सूत्रमग्रात् for (सूत्रात्मग्रात्) ४. व्यस्तोन्नतांश for (व्यस्तोन्नतांशा)

अथवा कपालके नाडिकादिसर्वं धनुष्फक्तं कर्त्तरि यंत्रम् ।

स्थूलं कृतं यतोन्त्यैर्वदामि ततः ॥ ३६ ॥

दिक्स्थितफलकद्वियुतिस्तले तदग्रस्थ सूत्रयोर्मध्ये ।

कीलस्तछायाग्रात् कर्त्तयानाडिका स्थूलाः ॥ ४० ॥

दष्टौच्यं समर्पिठं यष्टि व्यासार्द्धं मंकितं परिधौ ।

दिग्भगणांशं मूर्द्धन्यग्रा घटिकावि यष्ट्युक्तम् ॥ ४१ ॥

नलकोमूले विद्वस्तच्छूति घटिकोद्धत समुच्छायः ।

लब्धांगुलैस्तुतैर्नाडिका क्रियायंत्रसिद्धिरतः ॥ ४२ ॥

३६. (घ) १. स्थूलं (ग) (ङ) for (स्थूलं) (वि०— इसकी क्रमसंख्या ४० है)

(ग) २. नाडिकादिकं सर्वम् for (नाडिकादिसर्वं)

३. या धनुष्युक्तं for (धनुष्फक्तं) ४. पत्रम् for (यंत्रम्)

(वि०— इसकी श्लोकसंख्या ४३ है) (च) १. स्थूलं for (स्थूलं)

५. (वि०— क्रमसंख्या अंकित है)

(ङ) ३. यथा धनुष्युक्तं for (धनुष्फक्तं)

४. 'कर्त्तरियंत्रम्' दूसरी पंक्ति का आरम्भिकपद ।

४०. (घ) १. स्वछायाग्रा for (स्तछायाग्रात्) (वि०— इसकी क्रमसंख्या ४१ है)

२. कर्त्तया (ग) for (कर्त्तया) ३. नाडिकाः for (नाडिका)

(ग) (वि०— इसकी श्लोक संख्या ४१ है)

(च) २. कर्त्तयानाडिकाः for (कर्त्तयानाडिका) (वि०— इसकी क्रमसंख्या ४१ है)

(वि०— इसकी क्रमसंख्या ४१ है)

(ङ) २. कर्त्तया for (कर्त्तया)

४१. (घ) (वि०— इसकी संख्याक्रम ४२ है)

१. दष्टौच्यसमं (ग) दष्टौच्यं (ङ) for (दष्टौच्यं)

२. पीठं (ग) (ङ) for (पिठं) (ग) ३. ष्युक्तम् for (यष्ट्युक्तम्)

(च) १. दष्टौच्यं समं for (दष्टौच्यं सम) २. पीठं for (पिठं)

४. मूर्द्धन्यग्रा for (मूर्द्धन्यग्रा) (वि०— इसकी क्रम संख्या ४२ है)

(ङ) ५. मन्तिकं for (मंकितं) ३. रुक्तम् for (यष्ट्युक्तम्)

४२. (घ) (वि०— इसकी क्रमसंख्या ४३ है)

१. विद्वस्त (ग) विद्वस्तच्छूति for (विद्वस्तच्छूति) २. छूति for (छूति)

३. दूतस्तदुच्छायः for (समुच्छाय) (ग) ४. घटिकोद्धतः (ङ) for (घटिकोद्धत)

(वि०— इसकी श्लोक संख्या ४६ है) (च) (वि०— श्लोक संख्या ४३ है)

(ङ) १. तदुच्छूति for (तदुच्छूति)

घटिकांगुलांतरस्थे वीर्यांगुटकै घटोघृतेरन्यः ।

उपरिनरोतः शुषिरस्तिर्यक् कीलोस्य मुखमध्ये ॥ ४३ ॥

कीलो परिगामिन्यां वीर्याबद्धं सपारतमलांबु ।

स्त्रवति जलोक्षिपति नरो गुटिकां कुर्मोदयश्चैवम् ॥ ४४ ॥

जलपूर्णकृतघटोभिस्तनस्य कर्णादिभिर्जलं श्रिपति ।

पुरुषोन्यर्द्धो सत्त्वं चक्रचतुष्कस्य कृतमुपरि ॥ ४५ ॥

४३. (घ) (वि०—इसकी क्रमसंख्या ४४ है)

१. वीर्यांगुटकै (ग) वीर्यांगुडकै for (वीर्यांगुटकै)

२. घटोघृतेरन्यः for (घटोघृतेरन्यः) ३. उपरिनरोतः for (उपरिनरोतः)

(ग) ४. शुषिरस्तिर्यक् (ङ) for (शुषिरस्तिर्यक्)

(वि०—इसकी श्लोक संख्या ४७ है)

(च) १. वीर्या for (वीर्या)

(वि०—इसकी श्लोकसंख्या ४४ है)

(ङ) १. वीर्याङ्गुलकै for (वीर्यांगुटकै)

३. नरोतः for (नरोतः)

४४. (घ) ((वि०—इसकी क्रमसंख्या ४५ है) १. वीर्याबद्धं for (वीर्याबद्धं)

२. लांबु for (लांबु) ३. स्त्रवति (ग) (च) (ङ) for (स्त्रवति)

४. जले (ग) (च) (ङ) for (जलो)

५. कुर्मोदयश्चैवम् (ग) कुर्मोदयाश्चैवम् ॥ ४८ ॥ for (कुर्मोदयश्चैवम्)

(वि०—इसकी श्लोक संख्या ४८ है)

(च) २. लांबु for (लांबु)

५. कुर्मोदयश्चैवं for (कुर्मोदयश्चैवम्)

(ङ) १. वीर्याबंधं for (वीर्याबद्धं)

२. लांबु for (लांबु) ६. द्वारदम् for (सपारतम)

४५. (घ) (वि०—इसकी क्रमसंख्या ४६ है)

१. स्तनास्य (ग) (ङ) for (स्तनस्य)

२. पुरुषोन्यर्द्धासत्त्वं (ग) पुरुषोन्यर्द्धासत्त्वं for (पुरुषोन्यर्द्धोसत्त्वं)

(ग) ३. क्षिपितम् for (क्षिपति) ४. जनमुपरि ॥ ४९ ॥ for (कृतमुपरि ॥ ४५ ॥)

(वि०—इसकी श्लोक संख्या ४९ है)

(च) ३. क्षिपति for (क्षिपति)

२. न्यर्द्धा for (न्यर्द्धो) क्रमसंख्या ४६ है ।

(ङ) ३. क्षिपति for (क्षिपति) २. पुरुषोन्यर्धासत्त्वं for (पुरुषोन्यर्द्धोसत्त्वं)

एवं वफवरं नाडिकांगुलैः संस्थितेऽस्तरे योज्यम् ।

युद्धानि मल्लगज महिषमेष विविधयुधनृतां च ॥ ४६ ॥

निगिरति च घटिकां गुलाकितं गंडकं मयूरोऽर्ही ।

वीर्याभ्रुमेवं गुडकैरूपरिस्थं ब्रह्मचर्याद्यैः ॥ ४७ ॥

कालोक्षपाप्तिहितः पटहः शब्दकरोति घंटा वा ।

एवं यन्त्रं सहस्राण्यनेन बीजेन कार्याणि ॥ ४८ ॥

४६. (घ) १. वधुवरं (ग) (ङ) for (वफवरं) (वि०—इसकी क्रमसंख्या ४७ है ।)

(ग) २. संयुतं for (संस्थिते) ३. चरे (वरे) for (स्तरे)

४. विविधयुधनृतां च ॥ ५० ॥ (ङ) for (विविधयुधनृतां च)

(वि०— इसकी श्लोक संख्या ५० है)

(च) १. एवं च वरं for (एवं वफवरं)

४. विविधयुधनृतां च for (विविधयुधनृतां च) (वि०—श्लोक संख्या ४७ है)

(ङ) २. संयुता for (संस्थिते) ३. वरे योज्या for (स्तरे योज्यम्)

४७. (घ) (वि०— इसकी क्रमसंख्या ४८ है)

१. निगिरति गिरति च (ग) निगिरति गिरति for (निगिरति)

२. गंडकैर्मयूरोऽर्हिम् (ग) खंडकै for (गंडकै)

३. वीर्याभ्रुमेवं (ग) for (वीर्याभ्रुमेवं)

४. ब्रह्मचर्याद्यैः (ग) ब्रह्मचर्याद्यैः ॥ ५१ ॥ (ङ) for (ब्रह्मचर्याद्यैः)

(ग) ५. गुलाकितैः for (गुलाकितै) ६. मयूरोऽर्हिम् for (मयूरोऽर्हीम्)

(वि०—इस की श्लोक संख्या ५१ है)

(च) २. गंडकै for (गंडकै) ६. मयूरोऽर्हिम् for (मयूरोऽर्ही)

३. वीर्याभ्रुमेवं for (वीर्याभ्रुमेवं) ४. ब्रह्मचर्याद्यैः for (ब्रह्मचर्याद्यैः)

(वि०—श्लोक संख्या ४८ है) (ङ) २. खण्डकैर for (गंडकै)

६. मयूरोऽर्हिम् for (मयूरोऽर्ही) ३. वीर्याभ्रुमेवं for (वीर्याभ्रुमेवं)

४८. (घ) (वि०—इसकी क्रमसंख्या ४९ है)

१. कालोक्षपाप्तिहितः (ग) कीलोक्षपाप्तिहितः for (कालोक्षपाप्तिहितः)

२. यन्त्रसहस्राण्यनेन (च) (ग) for (यन्त्रसहस्राण्यनेन)

३. शब्दं (च) (ङ) for (शब्द)

४. 'वा' पद लुप्त है (वि०—इसकी श्लोकसंख्या ५२ है)

(च) १. कालोक्षपाप्तिहितः for (कालोक्षपाप्तिहितः)

(वि०—इसकी श्लोकसंख्या ४९ है)

(ङ) १. कीलोक्षपाप्तिहितः for (कालोक्षपाप्तिहितः)

लघुदारुमयं चक्रं समशुषिरांतरं पृथगराणाम् ।
 अर्धं पारदपूर्णं मध्ये सुल्लिष्टं कृतसंध्यौ ॥ ४९ ॥
 तिर्यक् कीलोमध्येध्व्याधारस्थो स्यपारदे व्रजति ।
 छिद्रान्यद्धं चक्रकर्मजभ्रमे वांबरे भ्रमति ॥ ५० ॥

४९. (घ) (वि०—इसकी क्रमसंख्या ५० है)

१. लघुदारमयं for (लघुदारमयं)
२. शुषिरांतरं for (शुषिरांतरं)
३. पारतपूर्णं (ग) परेतपूर्णं for (पारदपूर्णं)
४. सुल्लिष्टं (ग) संल्लिष्टं for (सुल्लिष्टं)

(ग) ५. चक्र for (चक्र)

६. दाम for (सम) ७. अर्धं for (अर्धं)
८. परिधौ for (मध्ये) १. कृतं संधिः ॥५३॥ for (कृतसंध्यौ)
- (वि०—इसकी श्लोकसंख्या ५३ है)

(च) १. लघुदारमयं for (लघुदारुमयं) ३. पारतपूर्णं for (पारदपूर्णं)

४. सुल्लिष्टं for (सुल्लिष्टं) (वि०—श्लोक संख्या ५० है)

(ङ) २. शुषिरान्तरं for (शुषिरांतरं)

द्वितीयपंक्ति—अर्धेरसेन पूर्णं परिधौ संल्लिष्टं कृतसन्धिः ।

for

अर्धं पारदपूर्णं मध्ये सुल्लिष्टं कृतसंध्यौ ॥

५०. (घ) १. द्वाचा (ग) (ङ) for (ध्व्या) (वि०—इसकी क्रमसंख्या ५१ है)

२. स्य पारते for (स्यपारदे) ३. छिद्राण्युध्वं (ग) (ङ) for (छिद्रान्यद्धं)

४. चक्रकर्मजसमेवांबरे (ग) चक्रकर्मजभ्रमेवांबरे भ्रमति ॥५४॥ for (चक्रकर्म-
 जभ्रमेवांबरे भ्रमति ॥५०॥)

(ग) ५. पारते for (पारदे)

६. भ्रमति (ङ) for (व्रजति)

(वि०—इसकी श्लोकसंख्या ५४ है)

(च) १. द्वाचाधारस्थो for (ध्व्याधारस्थो) २. स्य for (स्य)

५. पारते for (पारदे) ३. छिद्राण्यद्धं for (छिद्रान्यद्धं)

(वि०—श्लोकसंख्या ५१ है)

(ङ) २. स्य for (स्य)

५. पारदो for (पारदे) ७. + भ्रमति +

४. चक्रकर्मजभ्रमे for (चक्रकर्मजभ्रमे) ८. वांबरं for (वांबरे)

छिद्रे स्वधिया^५ क्षेप्यं^१ समं^१ तथा^१ पारदं^२ यदा^३ भ्रमति ।

कालसममिष्टमानैश्चक्रकमुत्तानमूर्ध्वं^४ वा ॥ ५१ ॥

कीलस्योपरिगमिभिन^१ तिर्यक्^३ सूत्रके^२ धूतमलाषु ।

प्राग्वन्नलके प्रक्षिप्य नाडिका श्रवति^५ पानीये ॥ ५२ ॥

५१. (घ) (वि०—इसकी क्रमसंख्या ५२ है)

१. प्येप्यं for (क्षेप्यं) (ग) 'क्षेप्यं' लुप्त है ।

२. पारतं (ग) (च) for (पारदं)

३. यथा (ग) (च) for (यदा)

मुत्तान (ग) (च) for (कमुत्तान)

(ग) ५. स्वधियां समं for (स्वधिया क्षेप्यं)
(वि०—इसकी श्लोक संख्या ५५ है)

(च) १. प्येप्यम् for (क्षेप्यम्)
(वि०—श्लोक संख्या ५२ अंकित है)

(ङ) १. क्षिप्त्वा for (क्षेप्यं)
३. 'यदा' लुप्त ।
६. यथा (for) तथा
४. समुत्तान for (कमुत्तान)
७. मूर्ध्वं वा for (मूर्ध्वं वा)

५२. (घ) (वि०—इसकी क्रम संख्या ५३ है)

१. गामिनि न (ग) गामिनितत्पर्यय for (गमिभिन)

२. मलाषु (ङ) मलाषु for (मलाषु)

(ग) (वि०—इसकी श्लोक संख्या ५६ है)

(घ) १. परिगामिनि (ङ) for (परिगमिभिन)
(वि०—श्लोक संख्या ५३ अंकित है)

(ङ) ३. तत्पर्यय for (तिर्यक्)

४. श्रवति for (श्रवति)

कर्णैर्ज्या क्षिप्रचलनमेव शरमोक्षशंस्वशबाश्च ।

अध्यायो द्वाविंशो यन्त्रेष्वार्यास्त्रिपञ्चाशत् ॥ ५३ ॥

इति ब्रह्मगुप्ते यन्त्राध्यायः (२२ वां अध्याय समाप्तः)

द्वाविंशः समाप्तः

५३. (घ) (वि०—इसकी क्रमसंख्या ५४ अंकित है)

१. मेवं (ग) (च) (ङ) for (मेव) २. शंखशब्दाश्च (ग) for (शंस्वशबाश्च)

३. इति ब्राह्मस्फुटसिद्धान्ते यन्त्राध्यायो द्वाविंशतितमः (ग) for (इति श्री ब्रह्म-
सिद्धान्ते यन्त्राध्यायो द्वाविंशः)

(ग) ४. चालन for (चलन) ५. सप्त for (स्त्रि)

(वि०—इसकी श्लोक संख्या ५६ है)

(च) २. शंखशब्दाश्च for (शंस्वशबाश्च)

(वि०—इसकी श्लोकसंख्या ५४ अंकित है)

३. इति ब्राह्मस्फुटसिद्धान्ते यन्त्राध्यायो द्वाविंशतितमः for (इति ब्रह्मगुप्ते
यन्त्राध्यायः (२२ अध्यायसमाप्तः))

(ङ) ६. करणैर्ज्या for (कर्णैर्ज्या) २. खशब्दाश्च for (स्वशबाश्च)

७. शरमोक्षणं for (शरमोक्षं)

३. इति ब्राह्मस्फुट सिद्धान्ते यन्त्राध्यायो नाम द्वाविंशोऽध्यायः for (इति ब्रह्म-
गुप्ते यन्त्राध्यायः)

अथ मानाध्यायो नाम

त्रयोविंशः

सौरैणाब्द^१ मास^२स्तितयश्चा^३न्द्रेण सावनै^४दिवसाः ।दिनमासाब्द^५ पम^६ध्यानत^७ द्विना^८कै^९दु माना^{१०}म्याम् ॥ १ ॥माना^{११}ति सौर^{१२}चन्द्रार्क्ष^{१३}सावनानि^{१४} ग्रहानयनमेभिः ।मानेन^{१५} पृथक्^{१६}चतुभिर्व्य^{१७}वहारो^{१८}त्र लोकस्य ॥ २ ॥युगववर्ष^{१९} विषुवदयनत्वह^{२०}निशो^{२१}र्वृ^{२२}द्धिहानयः ।सौरा^{२३}त्तिथि^{२४} करणा^{२५}धिकमासोन^{२६} रात्रपर्व^{२७}क्रियाश्चा^{२८}न्द्रात् ॥ ३ ॥यसस्य^{२९} वन^{३०} प्रमाण^{३१} ग्रहगत्फ^{३२}पवास^{३३} सूतक^{३४} चिकित्साः ।सावन^{३५} मानात्^{३६} ज्ञेया^{३७} प्रायश्चित्त^{३८} क्रियाश्चान्या^{३९} ॥ ४ ॥

१. (घ) १. सौरैणाब्दा (ग) सौरैणाब्दा (ङ) for (सौरैणाब्द)
 २. मासास्तितय (ग) (ङ) for (मासस्तितय)
 (ग) ३. मप for (पम) ४. तद्विनाकैदु for (तद्विनाकैदु)
 (च) १. सौरैणाब्दा for (सौरैणाब्द)
 २. मासास्तितयश्चा^३न्द्रेण for (मासस्तितयश्चा^३न्द्रेण) ५. दिवसा for (दिवसाः)
 २. (घ) १. चान्द्रार्क्ष (ग) चान्द्रार्क्ष for (चन्द्रार्क्ष)
 २. मानैः (ग) च (ङ) for (मानेन)
 ३. व्यवहारो^{१८}त्र (ग) संव्यवहाराश्च for (व्यवहारो^{१८}त्र)
 (ग) ४. पृथक् चतुभिः (ङ) for (पृथक्चतुभिः)
 (च) १. चान्द्रार्क्ष for (चन्द्रार्क्ष) ४. पृथक्चतुभिः for (प्रथक्चतुभिः)
 (ङ) ५. मानानि for (मानाति) ३. संव्यवहारो^{१८}त्र for (व्यवहारो^{१८}त्र)
 ३. (घ) १. युगवर्षे (ग) युगं वर्षं for (युगववर्ष) २. नंशो for (निशो)
 ३. हानियः for (हानयः)
 (ग) ४. सौरानतिथि for (सौरात्तिथि)
 (च) १. युगवर्ष (घ) for (युगववर्ष) ५. विषुवदय for (विषुवदय)
 २. नत्त्वहनिशो (ङ) for (नत्वहनिशो)
 ४. (घ) १. यज्ञसवन (ग) for (यसस्य वन)
 ग्रहगत्फुपवास (ग) ग्रहगत्फुपवास for (ग्रहगत्फपवास) ३. ज्ञेयाः (ग) for (ज्ञेया)
 (ग) ४. प्रायश्चित्त for (प्रायश्चित्त) ५. चान्याः ॥ ४ ॥ for (चान्या)
 (च) १. यज्ञस्य for (यसस्य) २. ग्रहगत्फुपवास for (ग्रहगत्फपवास)
 (ङ) १. यज्ञसवन for (यसस्य वन) २. गत्फुपवास for (गत्फपवास)
 ३. सावनमानाज्ञेयाः for (सावनमानात्ज्ञेया) ५. चात्र for (चान्या)

नक्षत्रसावनदिनात् सूर्यादीनां स्वसावन दिनानि ।
यस्मात्तस्मादाक्षं दुरधिगमं मन्दबुद्धिनाम् ॥ ५ ॥
मानुष्य पित्रदेव ब्राह्म्यान्यष्टा वमूर्त्तकालस्य ।
उक्तानि ज्ञानार्थं बार्हस्पत्यं नवममन्यत् ॥ ६ ॥
द्वौ द्वौ राशि मकराहतवः षट् सूर्यगति वशाद्योज्याः ।
शशिरवसन्त ग्रीष्मा वर्षा शरदौ सहेमन्ताः ॥ ७ ॥
भूव्यास गुणोभक्तः कर्क व्यासांतरेण रविकर्णं भूमध्या
द्ब्रूयाद्या दीर्घत्वं चन्द्रकर्णानि शेषम् ॥ ८ ॥

५. (घ) १. मन्दबुद्धिनाम् (ग) (ङ) for (मन्दबुद्धिनाम्)
(च) १. बुद्धिनां for (बुद्धिनाम्)
६. (घ) १. पित्र्यदेव (ग) पित्र्यदिव्य for (पित्रदेव)
२. ब्राह्म्यान्यष्टा (ग) for (ब्राह्म्यान्यष्टा)
बर्हस्पत्यं (ग) बार्हस्पत्यं for (बार्हस्पत्यं)
(च) १. पित्र्यदेव for (पित्रदेव)
४. नवममन्यत् for (नवममन्यत्)
(ङ) २. दिव्यपित्र्य for (पित्रदेव) ब्राह्म्यान्यष्टा for (ब्राह्म्यान्यष्टा)
७. (घ) १. राशी (ग) (ङ) for (राशि)
२. शशिरवसन्त (ग) शशिरवसन्त (ङ) for (शशिरवसन्त)
(ग) ३. मकराहतवः (ङ) (मकराहतवः)
(च) १. राशी for (राशि)
३. मकराहतवः for (मकराहतवः)
४. सहेमन्ता for (सहेमन्ताः)
(ङ) ५. वशादुभोज्याः for (वशाद्योज्याः) ६. शरदः for (शरदौ)
८. (घ) १. दीर्घत्वम् (ग) दीर्घत्वम् (ङ) for (दीर्घत्वं)
२. 'कर्ण' तक पहली पंक्ति समाप्त (ग) कर्णः (ङ) for (कर्णं)
३. 'कर्णानम्' तक दूसरी पंक्ति समाप्त (ग) (ङ)
४. 'शेषम्' अगले श्लोक का प्रथम पद है (ग) (ङ)
(च) १ दीर्घत्वं (ङ) for (दीर्घत्वम्)
४. ॥ ८ ॥ शेष for (शेषं ॥ ८ ॥)

व्यासगुणं दीर्घत्वहृतं शशांककक्षायाम् ।
 तमसो व्यासं शशि कर्णद्वृत्तस्त्रिज्यया गुणालिप्ता ॥ ९ ॥
 रविकर्णं दृता स्त्रिज्या कर्क व्यासान्तर हृता शोध्या ।
 त्रिज्यामूव्यास वधा छशि कर्ण हृतातमो व्यासः ॥ १० ॥
 भू व्यासेन्दुगति वधात् कर्क व्यासांतरार्कभुक्ति वधम् ।
 प्रोह्येन्दुमध्यभुक्त्या तिथिगुणयाप्तं तमो व्यासः ॥ ११ ॥
 योधिकमासावमरात्रसम्भवज्ञः सवेयिमानानि ।
 आर्याभिर्द्वादशाभिर्नाध्यायस्त्रयोविंशः ॥ १२ ॥
 इति ब्रह्म गुप्ते मानाध्यायः (२३ अध्याय समाप्तः)

९. (घ) १. यह पंक्ति 'शेषं से आरम्भ है शेषं 'पूव्यास' (ग) 'शेषं भू' लुप्त ।
 २. हृतं (ग) (च) (ङ) for (हृतं) ३. कक्षायाम् (च) for (कक्षायाम्)
 ४. गुणो (ग) (ङ) for (गुणो) ५. हृत (ग) (च) (ङ) for (दृत्त)
 (ग) ६. व्यासः (ङ) for (व्यास) ७. स्त्रिज्यो for (स्त्रिज्यया)
 ८. लिप्ताः for (लिप्ता) ९. दीर्घत्वं for (दीर्घत्व)
 (ङ) १. 'शेषं भू' लुप्त ७. स्त्रिज्या for (स्त्रिज्यया)
१०. (घ) ४. हृता (ग) (च) (ङ) for (दृता)
 २. तृज्या (ग) त्रिज्या (ङ) for (स्त्रिज्या)
 ३. व्यासांतराहृता (ग) (च) for (व्यासांतरहृता)
 ४. हृतं (ग) हृतातमो for (हृतातमो)
 (ग) ५. वधात् शशिकर्णं (ङ) for (वधाच्छशिकर्णं)
 (च) २. त्रिज्या for (स्त्रिज्या) ४. हृतातमो for (हृतातमो)
 (ङ) ६. व्यासांतराहृता for (व्यासांतरहृता) ४. हृतात् for (हृता)
११. (घ) १. प्रोह्येन्दु for (प्रोह्येन्दु) (च) १. प्रोज्येन्दु for (प्रोह्येन्दु)
१२. (घ) १. योधिक (च) for (योधिक) २. वेत्ति (ग) (च) (ङ) for (वेत्ति)
 ३. द्वादशभि (ग) (च) for (द्वादशाभिर्)
 ४. स्त्रयोविंशः (ग) (च) (ङ) for (स्त्रयोविंशः)
 ५. 'इति' से 'समाप्त' तक लुप्त है ।
 (ग) ६. सं भावज्ञः for (संभवज्ञः)
 (च) ५. 'इति' से 'समाप्त' तक लुप्त है ।
 (ङ) ३. आर्याभिर्द्वादशाभिर्यं for (आर्याभिर्द्वादशाभिर्)

अथ संज्ञाध्यायो नाम

चतुर्विंशः

यस्मात्संप्रति पत्तिर्न संज्ञया संज्ञितो विना तस्मात् ।
 लोकप्रसिद्धसंज्ञारूपादीनां शशांकाद्याः ॥ १ ॥
 युगपद्युगारूढया याम्यायां भास्करस्य वारूढ्याम् ।
 रात्र्यर्धात्सौम्याया मस्तमया दिनदलादैर्ध्राम् ॥ २ ॥
 अपमेवकृतः सूर्येण पुलिश रोमक वशिष्ठ यवनाद्यैः ।
 यस्मात्तस्मादेकः सिद्धान्तो ग्रन्थरचनान्याः ॥ ३ ॥
 यदि भिन्नाः सिद्धान्तभास्कर संक्रान्तयोपि भेदसमाः ।
 तस्पष्टः पूर्वस्यां विषुवत्पार्कोदयो यस्य ॥ ४ ॥
 तन्त्रपक्षागणितं मध्यम गत्युत्तरादयः पञ्च ।
 कुट्टाकारो वेधः छन्दश्चित्युत्तरं गोलः ॥ ५ ॥

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१. (घ) १. संज्ञिनो (ग) संज्ञिने for (संज्ञितो) (च) १. संज्ञिनो for (संज्ञितो)
 २. (घ) १. द्युगादि (ग) युगपत् युगादिरूढयात् for (युगपद्युगारूढया)
 २. दिनदलादैर्ध्राम् (ग) (ङ) for (दिनदलादैर्ध्राम्)
 (च) १. युगपद्युगादि for (युगपद्युगा) २. दिनदलादै for (दिनदलादै)
 (ङ) १. द्युगादिरूढया for (द्युगारूढया) ३. याम्यायां for (याम्यायां)
 ३. (घ) १. पुलिश for (पुलिश) २. ग्रन्थः (च) for (ग्रन्थ)
 (ग) ३. अपमेव for (अपमेव) ४. रचनान्या for (रचनान्याः)
 (ङ) ५. वशिष्ठ for (वशिष्ट) २. विरचितो for (ग्रन्थरच)
 ३. नान्यः for (नान्याः)
 ४. (घ) १. विषुवत्पार्को (ग) (च) for (विषुवत्पार्को)
 (ग) २. सिद्धान्तः (ङ) for (सिद्धान्त) ३. समाम् for (समाः)
 (ङ) ३. विभेद समाः for (विभेद समाः) १. विषुवत्पार्कोदयो for (विषुवत्पार्कोदयो)
 ५. (घ) १. तन्त्रपरीक्षागणिते (ग) तन्त्रपरीक्षागणितम् for (तन्त्रपक्षागणितम्)
 २. चित्युत्तरं गोलः (ग) (च) for (चित्युत्तरं गोलः)
 (च) १. तन्त्रपक्षागणिते for (तन्त्रपक्षागणितं) ३. कुट्टाकारो for (कुट्टाकारो)
 (ङ) १. तन्त्र परीक्षा for (तन्त्रपक्षा) ४. वेद्यश्छन्द for (वेधः छन्द)
 २. श्चित्युत्तरं गोलः for (श्चित्युत्तरं गोलः)

यंत्राणिमान संज्ञाश्चैवाध्यायाश्चतुर्दश ब्रह्मोऽध्यायः ।

अतुविंशतिराद्यं द्दंशभिः सहाध्यायः ॥ ६ ॥

श्रीचापवंशतिलके श्रीव्याघ्रमुखे नृपे शकनृपाणाम् ।

पञ्चाशत्संयुक्तैः वर्षशतैः पञ्चभिरतीतैः ॥ ५५० ॥ ७ ॥

ब्रह्मस्फुटसिद्धान्तैः सज्जनगणितगोलविप्रित्यै ।

त्रिंशद्वर्षेण ततो जिष्णुमुतब्रह्मगुप्ते ॥ ८ ॥

गणितेन फलं सिद्धं ब्राह्मे ध्यान ग्रहे यतोऽध्याये ।

ध्यानग्रहो द्विसप्तत्यार्याणां न लिखितोऽत्र मया ॥ ९ ॥

६. (घ) १. ब्राह्मो अध्यायः for (ब्रह्मोऽध्यायः) (ग) ब्राह्मो for (ब्रह्मो)

(वि०—यहां प्रथम पंक्ति समाप्त)

२. दंशभिः (ग) (च) (ङ) for (द्दंशभिः)

(ग) ३. संज्ञारव्यो for (संज्ञाश्चै) ४. चाध्याय for (वाध्याया)

५. 'अध्यायः' से दूसरी पंक्ति आरम्भ (ङ)

(च) ५. अध्यायाः for (ध्यायः)

(ङ) ३. ख्याता for (श्चैवा) १. ब्राह्मे for (ब्रह्मो)

६. युताध्यायैः for (सहाध्यायैः)

७. (ग) १. नृपानाः for (नृपाणाम्) २. पञ्चशतसंयुक्तैः for (पञ्चाशत्संयुक्तैः)

३. वर्षशतैः for (वर्षशतैः) ४. '५५०' संख्या लुप्त है ।

(घ) ५. श्रीचापविशतिलके for (श्रीचापवंशतिलके)

६. पञ्चभिरतीतैः for (पञ्चभिरतीतैः)

(ङ) ३. संयुक्तैर्वर्षशतैः for (संयुक्तैः वर्षशतैः)

८. (घ) १. विप्रित्यै (ग) वित्प्रीत्यैः for (विप्रित्यै)

२. ततो (ग) कृतो (ङ) for (ततो) (ग) ३. ब्राह्मः (ङ) for (ब्रह्म)

४. स्फुटसिद्धान्तैः (ङ) for (स्फुटसिद्धान्तैः) ५. गणितज्ञ for (गणित)

६. गुप्तेन (ङ) for (गुप्ते) (च) ५. सज्जनगणित for (सज्जनगणित)

१. विप्रित्यै for (विप्रित्यै) २. ततो for (ततो)

(ङ) १. वित्प्रीत्यै for (विप्रित्यै)

९. (घ) १. लिखितोऽत्र (ङ) for (लिखितोऽत्र) (ग) २. सिधं for (सिद्धं)

(च) ८. ब्रह्मे for (ब्राह्मे) (ङ) ४. फले for (फलं)

२. सिद्धिब्राह्मे for (सिद्धब्राह्मे) ६. यतोऽध्याये for (यतोऽध्याये)

५. द्विसप्ततिरार्याणां for (द्विसप्तत्यार्याणां)

तिथिभोगनाडिकासु द्विगुणास्त्रिगुणा खे शोध्याः ।
 पंचाशीत्यंशोनास्तिथि नाडीशोधयेच्छ्रुतिनः ॥ १२ ॥
 वेदहतौ नवभक्तौ राश्यादौ दिनकरोडुपकेंद्रम् ।
 त्रिगुणं सप्त विभक्तं गजाद्रयोशा रवेरुच्चम् ॥ १३ ॥
 विकला संयुक्तं नव बाणा लिप्तिकारवेभुक्तिः ।
 खनवनगा शीतांशोः पंचत्रिंशद्विलिप्ताश्च ॥ १४ ॥
 स्वोच्चोनकेंद्रमिनो नवभिर्लिप्ता शतै जीवा ।
 विषमे भुक्तस्य समे भोग्य सदैव केंद्रपदे ॥ १५ ॥
 त्रिंशत्सनवरसेंदुः ॥ १६ ॥
 गतभोग्य खंडकांतरे दल ॥ १७ ॥

१२. (ङ) १. रसगुणोद्धृताः शोध्याः for (स्त्रिगुणा खे शोध्याः)

२. पंचाशीत्यधिको for (पंचाशीत्यंशो) ३. नाड्यः for (नाडी)

१३. (ङ) १. (वि०—इस श्लोक का उत्तरार्ध—१४ वें श्लोक का पूर्वार्ध भी है)

त्रिगुणं सप्त विभक्तं नगाद्रयोशा रवेरुच्चम् ।

विकलाष्टकं संयुक्ता नवबाणा लिप्तिका ५६।८ रवेभुक्तिः ॥ १३ ॥

for

(वेदहतौ नवभक्तौ राश्यादौ दिनकरोडुपकेंद्रम् ।

त्रिगुणं सप्त विभक्तं गजाद्रयोशा रवेरुच्चम् ॥ १३ ॥)

१४. (ङ) (वि०—इस श्लोक का पूर्वार्ध, १३ वें श्लोक का उत्तरार्ध भी है)

१. विकलाष्टकं for (विकला)

२. संयुक्ता for (संयुक्त)

१५. (ङ) १. त्वोच्चोनं for (स्वोच्चोन) २. मिनो for (मिनो)

३. शतैस्ततो for (शतैर्जीवा) ४. भोग्यस्य for (भोग्य)

१६. (ङ) १. त्रिंशत्सनवरसेंदुर्जिनतिथि विषया गृहार्धचापानाम् ।

अर्धज्याखंडानि ज्याभुक्तैश्च सभोग्य फलम् ॥ १६ ॥

for

(त्रिंशत्सनवरसेंदुः ॥ १६ ॥)

२. गतभोग्यखण्डकान्तरदलविकलवधाच्छतैर्नवभिराप्तैः ।

तद्युतिदलं युतोर्न भोग्याद्वनाधिकं भोग्यम् ॥ १७ ॥

for

(गतभोग्य खंडकांतरेदल ॥ १७ ॥)

स्पाप्तांशोना सवितु^२ द्विगुणा^३ ज्याशीतगौ^३ फलं लिप्ताः ।
 स्वफलमृणं चक्राद्वाद्ने केंद्र^१ेधिके धनं मध्ये ॥ १८ ॥
 नगमूहद्रविभोग्यं खंडं चांद्रं मत्त भागोनं ।
 द्विगुणं भुक्तिफलं स्वमृणं स्यात्कुलीरमकरा^३दिकेंद्र^३े ॥ १९ ॥
 भांशोर्कफलस्येदौ रविवद्विशोद्धतः स्वोर्क^२ रवि ।
 फलमिनवतिथौ चांद्रव्यस्तः स्फुटार्काप्तम् ॥ २० ॥
 पंचेषु पंचयुगगुणयम चंद्राशुचंद्रकेन्द्र भफलानि ।
 द्विद्विद्विद्विकुभुवः षटक्षर हिते त सूर्यम् ॥ २१ ॥
 भान्यश्विन्यादीनि ॥ २२ ॥
 अर्कोनचंद्रलिप्ता ॥ २३ ॥

१८. (ङ) १. स्वाष्टांशोना for (स्पाप्तांशोना)
 २. द्विगुणा for (द्विगुणा) ३. गौः for (गौः)
 ४. 'धनम्' पद लुप्त है ।
१९. (ङ) १. विव सुलवं for (मत्तभागोनं)
 २. 'द्विगुणं' यहां यह पद प्रथम पंक्ति का समापक है ।
 ३. मकरादिके for (मकरादिकेंद्रे)
२०. (ङ) १. रविवद्वा द्विशोधिते तथा स्वोच्चे for (रविवद्विशोद्धतः स्वोर्क)
 २. यहां 'रवि' पद दूसरी पंक्ति का आरंभक है ।
 ३. नवच्च तिथौ for (नवतिथौ) ४. चांद्रे for (चान्द्र)
 ५. व्यस्तं for (व्यस्तः)
२१. (ङ) १. चंद्राश्चन्द्र for (चन्द्राशुचन्द्र) २. ज for (भ)
 ३. द्विकुभुव खरहिते for (द्विद्विद्विद्वि कुकुभवः षटक्षरहिते)
 ४. तथा सूर्ये.....for (तसूर्यम्)
२२. (ङ) १. अर्कोनचन्द्रलिप्ताः खयमस्वरभाजिताः फलं तिथयः ।
 गतगम्ये षष्टिगुणे भुक्त्यन्तरभाजिते षटिकाः ॥ २२ ॥
 for
 (भान्यश्विन्यादीनि ॥ २२ ॥)
२. भान्यश्विन्यादीनि ग्रह लिप्ताः खखवसूद्धता लब्धम् ।
 भुक्तिद्विते गतगम्ये दिवसाः षष्ट्याहते षटिका ॥ २३ ॥
 for
 (अर्कोन चन्द्रलिप्ताः ॥ २३ ॥)

^१व्यकेंदुफलाक्ताः ॥ २४ ॥

^२रविचन्द्र योग लिप्ताः ॥ २५ ॥

इति तिथ्यधिकारः ॥

अंगं रुद्रैः सिद्धैर्गजैर्जनैरर्कं वत्सरात् ॥ ६ ॥ ११ ॥ २४ ॥ ८ ॥ २४ ॥

शैलैर्विलैर्गुणैरसवत्क्षिभिर्योजयोद्भौमः ॥ ७ ॥ ६ ॥ ३२ ॥ २६ ॥

^१शशिनोक्षितैः शराविरकैः षड्वत्क्षिभिर्हृतानंदान् ।

शशिना द्वियमैश्चतुरविभिर्दिनैर्युतं भवति बुधशीघ्रम् ॥ २७ ॥

रूपेण खेनकुयमैरंगैर्नभसावकरणारव्यब्दात् ।

गुणिता युक्ता वेदैः कुयमैस्त्रियमैर्गुणैश्च गुरुः ॥ २८ ॥

२४. (ङ) १. रविचन्द्र योगलिप्ताः खखवसुभिर्भाजिताः फलं योगः ।

गतगम्ये षष्टिगुणे गतियोनिभाजिते घटिकाः ॥ २४ ॥

for

(व्यकेंदुफलाक्ताः ॥ २४ ॥)

२५. (ङ) १. व्यकेंदुफला भक्ताः खरसगुणैर्लब्धमूनमेकेन ।

चरकरणानि ववादीन्यगताच्छेषात् तिथिवदन्यत् ॥ २५ ॥

for

(रविचन्द्रयोगलिप्ताः ॥ २५ ॥)

२६. (ङ) १. यमैरर्कवत्सरात् गणयेत् for (जिनैरर्कवत्सरात्)

२. विश्वैर्गुणितै for (विलैर्गुणै) ३. षष्टवत्क्षिभि for (रसवत्क्षिभि)

४. योजयेत् for (योजयोद्भौमः)

२७. (ङ) १. शशिना जिनैः रकैः षड्वत्क्षिभिर्हृतादब्दात्

for

(शशिनोक्षितैः शराविरकैः षड्वत्क्षिभिर्हृतानंदान् ।)

२८. द्विपैर्यमैश्चतुरविभिर्दिनैर्युतं for (द्वियमैश्चतुरविभिर्दिनैर्युतं)

२८. (ङ) १. +१+ २. +२१+ ३. +६+

४. नवभिश्चकरणब्दाः for (नभसावकरणारव्यब्दात्)

५. वेदैः for (वेदैः)

६. यमैश्च भवति गुरुः ॥ २८ ॥

for

(यमैर्गुणैश्च गुरुः ॥ २८ ॥)

शैले^१स्तिथिभी ख^२यंम विषयैर^३स्त सागरै^४गुणिता ।
 वसुभि^५रनलै^६जिनैः ख^७ङ्गुणैश्च शुक्रा भृगोः शीघ्रम् ॥ २९ ॥
 शून्येन द्वादशभिर्द्वादशभिः दद्वि^८शिभिः खेषु^९भिस्त्रयोदभिः ।
 गुणिता युक्ता रसरवि^{१०}तिथिविषयैर्वंशभिर^{११}कैः ॥ ३० ॥
 गगने ननंद चन्द्रैः^{१२} क्यमैरसाधिभिरं बरेण^{१३} हताः ।
 ख^{१४}नृपैः खवेदै^{१५}युक्ता राश्यादिको^{१६} राहुः ॥ ३१ ॥
 सर्वाणि स्थानानि क्रमात्स्वहरै^{१७}नयै^{१८}दुपयुं परि ।
 एवं रव्यब्दांते ग्रहध्वास्तत्परांशाः स्युः ॥ ३२ ॥
 पृथग^{१९}को दिग्गुणितो वसुशरच^{२०}हृतः फलेन युतः ।
 दलितो भौमध्रुवके क्षिप्तः स्यान्मध्यमो भौमः ॥ ३३ ॥
 चतुराहतो विवस्वान पृथक् सस्ताहतो न विधृति विभक्तः ।
 फलसंयुक्तादेयो जचलध्रुवके ज्ञशीघ्रं स्यात् ॥ ३४ ॥

२९. (ङ) १. 'रस्त' पद लुप्त है । २. रनलै for (रनलै)
 ३. षङ्गुणैश्च for (खङ्गुणैश्च) ४. युक्तम् for (शुक्रा)
 ३०. (ङ) १. 'दद्विशिभिः' पद लुप्त है । २. युता for (युक्ता)
 ३. रसरविभिस्त्रिविषयै for (रसरवितिथिविषयै)
 ४. राकिः ॥ ३० ॥ for रकैः ॥ ३० ॥
 ३१. (ङ) १. गगनेन नवचन्द्रैः for (गगने ननंद चन्द्रैः)
 २. रसाब्धिभिः for (रसाब्धिभि) ३. संबरेण for (रंबरेण)
 ४. हताः for (हताः) ५. 'नृपैः' पद लुप्त है ।
 ६. कः पातः ॥ ३१ ॥ for (कः पातः ॥ ३१ ॥)
 ३२. (ङ) १. क्रमतः for (क्रमात्) २. नयैदुपरि for (नयैदुपयुं परि)
 ३. ध्रुवा for (ध्रुवास्)
 ४. मध्यमाः स्युस्ते for (तत्परांशाः स्युः)
 ३३. (ङ) १. दशगुणितो for (दिग्गुणितो) २. चंद्रैहृतः for (चंहृतः)
 ३. क्षेप्यः for (क्षिप्तः)
 ३४. (ङ) १. ज्विगुणितः for (विवस्वान) २. च सप्ताहतो for (सस्ताहतो)
 ३. ज्विधृतिभक्तः for (न विधृतिविभक्तः)
 ४. संयुतो विषयो for (संयुक्तादेयो)
 ५. ध्रुवको for (ध्रुवके)

भट ब्रह्माचार्येण^१ जिष्णुस्तनयेन^२ गणितगोलविदा ।
 आर्याष्टसहस्रेण^३ स्फुटसिद्धान्ते^४ ऋतो ब्रह्मा ॥ १० ॥
 भग्रह युति वतशंकु^५ वित्रिभलग्नावविग्रहोक्तसमः ।
 शशिनः कर्मबहुत्वान्नकृतातो भास्करग्रहणे ॥ ११ ॥
 आज्ञेयी नैरुत्योरुद्दिष्टदिने स्थितस्य योऽर्कस्य ।
 शंकुछाये कथयत्यब्दापि वेत्ति सूर्यशः ॥ १२ ॥
 अत्र मया यन्तोक्तं गोलादप्रक्षयधिमतोह्यं तत् ।
 आर्यात्रयोदशोऽयं संज्ञाध्यायश्चतुर्विंशः ॥ १३ ॥

१०. (घ) १. सहस्रेणः (ग) सहस्रेण for (सहस्रेण)
 २. सिद्धं ते (ग) सिद्धांतः (ङ) for (सिद्धान्ते) ३. कृतो (ग) (च) (ङ) for (कृतो)
 (ग) ४. ब्रह्माचार्येण for (ब्रह्माचार्येण) ५. ब्राह्मः for (ब्रह्मा)
 (च) १. सहस्रेणः for (सहस्रेण), (ङ) ६. जिष्णुस्तनयेन for (जिष्णुस्तनयेन)
११. (घ) १. नग्रह for (भग्रह) २. नाच्छंकु for (वतशंकु)
 ३. शशिनः for (शशिनः) ४. बहुत्वान्ने for (बहुत्वान्न)
 ५. कृतोऽतो (ङ) for (कृतातो), (ग) ६. वित्रिभलग्नात् for (वित्रिभलग्नाद्)
 (च) ५. बहुत्वान्नकृतोऽतो for (बहुत्वान्नकृतातो)
 (ङ) २. वच्छंकु for (वतशङ्कु) ७. ग्रहोक्तसमः for (ग्रहोक्तसमः)
१२. (घ) १. आज्ञेयीनैरुत्यो (ग) आज्ञेयीनैरुत्यो for (आज्ञेयीनैरुत्यो)
 २. रुद्दिष्टदिने for (रुद्दिष्टदिने) ३. स्थितस्य योऽर्कस्य for (स्थितस्य योऽर्कस्य)
 ४. कथयत्या ... (ग) कथयत्यब्दापि for (कथयत्यब्दापि)
 ५. सः (ग) (ङ) for (शः), (च) १. आग्नेये for (आज्ञेयी)
 ६. नैरुत्ये for (नैरुत्यो) २. वेष्टदिने for (रुद्दिष्टदिने)
 ३. संस्थितस्य for (स्थितस्य) ४. कथयति वर्षादपि for (कथयत्यब्दापि)
१३. (घ) १. दत्प्रक्षय (ग) दुत्प्रक्षय for (गोलादप्रक्षय)
 २. आर्यात्रयोदशो (ग) आर्यात्रयोदशाय for (आर्यात्रयोदशोऽयं)
 ३. चतुर्विंशः (ग) for (चतुर्विंशः)
 (ग) ४. (वि०—यहाँ समाप्तिसूचक ॥छः॥ ॥छः॥ ॥छः॥ अंकित है)
 (च) १. गोलादप्रक्षय for (गोलादप्रक्षय)
 ४. धीमती for (धिमतो) २. आर्यात्रयोदशोऽयं for (आर्यात्रयोदशोऽयं)
 ३. चतुर्विंशः (ङ) for (चतुर्विंशः) (ङ) १. गोलादुत्प्रक्षय for (गोलादप्रक्षय)
 ४. धीमता for (धिमतो) ५. वोह्यम् for (ह्यं तत्)
 (वि० + इति श्रीमदाचार्य जिष्णुसुतब्रह्मगुप्तविरचिते ब्राह्मस्फुटसिद्धान्ते
 संज्ञाध्यायश्चतुर्विंशतितमः सम्पूर्णतामगमत् +)

गणितं बहुप्रकारं गोलो यंत्राणि यत्र कथितानि ।

स ब्रह्मगुप्तविहितः स्फुट सिद्धांतो स्मृतो ब्रह्म ॥ १४ ॥

सिद्धांतैपि स ब्राह्मणं तपसा भक्त्या वयो महादेवम् ।

आराध्यकर नमस्तस्मै श्री ब्रह्म गुप्ताय ॥ १५ ॥

इति श्री भिलमाचार्यभट्ट जिष्णु सुत ब्रह्मगुप्तविरचिते ब्राह्म-

स्फुटसिद्धान्ते संज्ञाध्यायः

ब्रह्म गुप्त सिद्धांतः समाप्तः ॥

१४. (घ) १. विहितः (च) for (विहितः) २. सिद्धांतः (च) for (सिद्धान्तो)

३. ब्रह्मः for (ब्रह्म) (ग) 'ग' में यह श्लोक अंकित नहीं है ।

(च) ३. ब्रमः for (ब्रह्म)

४. क्रमसंख्या—१ for (१४)

(ङ) श्लोक अनुपलब्ध है ।

१५. (घ) १. संब्राह्मणं for (संब्राह्मणं) २. (च) +च+

३. आराध्य च कर for (आराध्यकर) ४. भिल्लमा for (भिलमाचार्य)

५. भट्ट for (भट)

६. अतिरिक्तपाठ—चतुर्विंशतितमः समाप्तोऽयं श्रीब्रह्मगुप्तकृतो ब्रह्मस्फुट सिद्धांतः । ब्रह्मसिद्धांतबीजानि । खखखांक्क हताप्येभ्योः । १२००० गतग-म्याल्पात एव शून्य यमलहता । २००, तल्लब्धं त्रि ३ सायक ५ हतं कलाभिरूनौ । सदाक्केदु विधुवद् जीवेद्वि १२ । हतंचंद्रोस्वतिथि १५ गुणं च शतशीघ्रे द्वीषु ५२ हतं स्वक् चलेद्विक्कु १ वेदधहतं च पातकुजशनिषु २ कल्याणं भूयात् ॥१॥ संवत् १५५४ वर्षे फाल्गुणवदि ४ चतुर्थी रवौ लिखितं भयपुरवास्तव्य रेवातटे वास्तव्य ब्रह्मसिद्धांतः । ग्रंथ संज्ञा ।

(ग) 'ग' में यह श्लोक अंकित नहीं है । (ङ) श्लोक अनुपलब्ध है ।

चतुर्विंशतितमः समाप्तोऽयं श्रीब्रह्मगुप्तकृतो ब्रह्मस्फुटसिद्धांतः । ब्रह्मसिद्धांत-बीजानि खखखांक्क हताप्येभ्यो १२००० गतगम्याल्पात एव शून्य यमलहता २०० तल्लब्धं त्रि ३ सायक ५ हतं कलाभिरूनौ सदाक्केदु विधुवद् जीवेद्वि २ हतं चंद्रोस्वतिथि १५ गुणं च शतशीघ्रे द्वीषु ५२ हतं स्वक्चलेद्विक्कु १ वेद ४ हतं च पात कुजशनिषु । २ कल्याणं भूयात् १ श्री ॥ श्री ॥ for (ब्रह्मगुप्त सिद्धांतः समाप्तः)

अथ ब्रह्मगुप्तकृतो ध्यानग्रहोपदेशाध्यायः

॥ ॐ नमः श्री सरस्वत्यै ॥

पंचाशत्संयुक्तैर्बर्षशतं पंचभिर्विना शाकः ।

त्रिस्थोर्केर्वसुवेदैर्नवचन्द्रैस्ताडितः क्रमशः ॥ १ ॥

समायकसंयुक्तः खजिन २४० विभागो नितः सयमवेदैः ।

मध्यमराशिः शशिविश्वभाजिततोऽह्यधिक मासा स्युः ॥ २ ॥

तैरुपरितनो युक्तो मासगणोऽभ्यधिक शेषके शुद्धे ।

घटिकादिकं भचक्राद्रविरवशेषो भवेद्भादि ॥ ३ ॥

रूपेण रूपरामैः खसायकैस्ताडितो गुणो युक्तः ।

षड्भिः करैश्च दिग्भिराघटिकां विघटिका स्युः ॥ ४ ॥

खखरसलब्धं घटिकासु नियोजये तिथिघ्न ।

रव्यादिकस्तदुदये चैत्रदवेर्कं चन्द्रो वा ॥ ५ ॥

१. (ङ) १. शतैः for (शतै) २. त्रिष्ठोर्के for (त्रिस्थोर्के)

२. (ङ) १. पंचाब्धियुतोऽधः षष्टिभाजितो लब्धियुक् सरसवेदः ।
for

समायक संयुक्तः खजिन २४० विभागो नितः सयमवेदैः ।

२. मध्यमराशि विश्वविभाजितोऽभ्यधिकमासाः स्युः ॥ २ ॥

for

मध्यमराशिः शशिविश्वभाजिततोऽह्यधिक मासा स्युः ॥ २ ॥

३. (ङ) १. शेषकः for (शेषके) २. शुद्धः for (शुद्धे)
३. घटादिको for (घटिकादिक) ४. रविशेषो for (खशेषो)
५. भवेद्भादि ॥ ३ ॥ for (भवेद्भादि) ॥ ३ ॥

४. (ङ) १. गणो for (गुणो) २. वेदैर्धृत्या for (करैश्च)
३. वासरघटिका for (दिग्भिराघटिकां)

५. (ङ) १. नियोजयेत् for (नियोजये) २. तिथिघ्नवकाः for (तिथिघ्न)
३. चैत्रादावर्कं for (चैत्रदवेर्कं) ४. चन्द्रो for (चन्द्रो)
५. च for (वा)

मासगुणो यमगुणितः पृथक् द्विततो^३द्वतः फलसमेतः ।
 सार्धात्तृधुतो वसुयम विभक्तः शेषाधोः केन्द्रम् ॥ ६ ॥
 चैत्रादिमासगुणिते द्वे नक्षत्रे क्षिपेत्सहस्रांशौ ।
 घटिकैकादशयुक्तः सार्द्धेन^२ व पलेन^३ रहिते वा ॥ ७ ॥
 नाड्यर्द्धेन समेतं द्वितयं प्रक्षिपेच्च शशिकेन्द्रे ।
 रूपं रूपं हुतांशांशराश्च तिथिध्रुवे क्रमशः ॥ ८ ॥
 वारं दद्यात्प्रतिदिनमब्धिपलोनां परित्यजेन्नाडीम् ।
 केन्द्रे क्षिपेद्भूमेकं सद्द्वियमलं घटीचतुष्कमितौ ॥ ९ ॥
 उज्जयिनी याम्योत्तर रेखायाः प्राग्धनं क्षयः पश्चात् ।
 योजनखाष्टि ८० नाडी चरदलमपि सौम्य दक्षिणयोः ॥ १० ॥
 तिथियो दशभागो^२ रविधिष्यसमन्विताः शशीमध्यः ।
 तिथिभोग नाडिकोनं कर्त्तव्यं शीतगोः केन्द्रः ॥ ११ ॥

६. (ङ) १. मासगुणो for (मासगुणो) २. कुतत्त्वोदृतः for (द्विततोदृतः)
 ३. सार्धाष्ट for (सार्धात्तृ)
 ४. ५. विभक्तशेषो विधोः for (विभक्तः शेषाधोः)
 ७. (ङ) १. युक्त for (युक्तैः) २. फलेन for (वपलेन)
 ३. सहिते for (रहिते) ४. च for (वा)
 ८. (ङ) १. हुतांशाः for (हुतांशां)
 ९. (ङ) १. भद्रियमलं for (सद्द्वियमलं) २. मिते for (मितौ)
 १०. (ङ) १. उज्जयिनी for (उज्जयिनी)
 २. षष्ट्या नाडी for (खाष्टि ८० नाडी)
 ११. (ङ) १. तिथयो for (तिथियो) २. भागोना for (भागो)
 ३. रविणा समन्विता for (रविधिष्यसमन्विता)
 ४. शशी भवति मध्यः for (शशीमध्य)
 दूसरी पंक्ति — तिथ्यंशादथा शोष्यास्तिथि भोगजनाडिकाः केन्द्रात् ।

for

तिथिभोगनाडिकोनं कर्त्तव्यं शीतगोः केन्द्रः ॥

सप्तहस्त्रिवसुहृतो गुरोः शनिद्विगुणितो नवेषु हृतः ।
 दिग्गुणितो रसधृतिहृद्राहो लिप्ता सुकृतलिप्ताः ॥ ३५ ॥
 त्रिगुणो दलितः शुद्धादशयुक्तसित चलध्रुवे देयः ।
 तात्कालिकं चलं स्याद्रविरन्येषां जशुकौ सहः ॥ ३६ ॥
 मंदांशो नगरवयो भयमाः खनगेंदवः खनंदाश्च ।
 यमतत्वानि तद्वनान्यथाज्ञात्सूर्यवद्ग्राह्याः ॥ ३७ ॥
 रदगुणिता सप्तकृता कुजस्य सौम्यस्य युगगुणा गताः ।
 द्विगुणैव फलं सूर्यद्विगुणा त्रिभाजिताः स्फुजिताः ॥ ३८ ॥
 श्र्यंशद्भागोनास्य त्रिगुणारविजाय मंदफलं लिप्ताः ।
 मंदफलदलोनयुतं शीघ्रोच्चात् शोधयेन्मध्यः ॥ ३९ ॥
 तस्मात् शीघ्रफलदलं स्वमृणं वामंदसंस्कृतं कृत्वा ।
 प्राग्वनमंदफलमतः सकलं मध्यग्रहे कुर्यात् ॥ ४० ॥

३५. (ङ) १. हृत for (हस्त्रिव) २. दिग्गुणितो for (दिग्गुणितो)
 ३. लिप्तः for (लिप्ता)
 ३६. (ङ) १. स्वद्वादशांशयुक्तः for (शुद्धादशयुक्तः)
 २. सितचलं ध्रुवं स्यात् for (सितचलध्रुवे देयः)
 ३. स्तः for (सहः)
 ३७. (ङ) १. मंदांश for (मंदांशो) २. तद्वनान्मध्याज्या for (तद्वनान्यथाज्ञात्)
 ३. सूर्यवत् ग्राह्या for (सूर्यवद्ग्राह्याः)
 ३८. (ङ) १. हृता for (कृता) २. नगगुणा for (युगगुणा)
 ३. त्रिहृता for (गताः) ४. द्विगुणा हि for (द्विगुणैव)
 ५. गुणाग्निविभाजिता for (गुणात्रिभाजिताः)
 ६. स्फुजितः for (स्फुजिताः)
 ३९. (ङ) १. त्रिगुणा त्रिशङ्कता रविजस्य फलस्य मंदफललिप्ताः ।
 मन्दफलयुतोनं स्वशीघ्रोच्चाच्छोधयेन्मध्यम् ॥ ३९ ॥
 for
 श्र्यंशद्भागोनास्य त्रिगुणारविजाय मंदफलं लिप्ताः ।
 मंदफल दलोनयुतं शीघ्रोच्चात् शोधयेन्मध्यः ॥ ३९ ॥
 ४०. (ङ) १. संस्कृते for (संस्कृतं) २. दत्त्वा for (कृत्वा)
 ३. प्राग्वनमंद for (प्राग्वनमंद) ४. मान्दग्रहात् for (मध्यग्रहे)

तस्मत्पृथक् स्थितादपि शीघ्रोच्चाट्षितशोधिताच्चफलेन ।
 सकलेन संस्कृतो मृदुफलस्फुटो जायते स्पष्टः ॥ ४१ ॥
 भागीकृतचलकेन्द्रत्रिगुणैश्चद्युद्धते फलं पिडा ।
 षड्राशधिकेन चक्राद्विशुद्धशेषे तथैव स्यात् ॥ ४२ ॥
 पिडांतरेण गुणितं शाखं खाद्युद्धतक्रमं देयम् ।
 उत्क्रमविधौ विशोध्यं गतपिडे शीघ्रफलमेत् ॥ ४३ ॥
 पिडतवि विकरां गुणौ यदाद्येन पिडके ततः ।
 यत्नम्यते खवेदस्तदेव फलमत्र बोद्धव्यम् ॥ ४४ ॥
 पिडे चतुर्दशे विश्वपिडगुणितान्मखोद्धृताद्धि कलात् ।
 लब्धेन विद्वपिडो रहितः शेषं फलं भवति ॥ ४५ ॥

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४१. (ङ) १. तस्मात् for (तस्मत्) २. मितादि for (स्थितादपि)
 ४. विवर्जितात् (स्फुटकेन्द्रम्) for (आट्षितशोधिताच्च फलेन)
 ५. तस्मात् शीघ्र फलेन संस्कृतः for (सकलेन संस्कृतो)
 ६. 'मृदुफल' पद लुप्त है।
४२. (ङ) १. केन्द्रे for (केन्द्र) २. त्रिगुणौ for (त्रिगुणैश्च)
 ३. खान्युद्धते for (च द्युद्धते) ४. पिडः for (पिडा)
 ५. षड्राशधिके for (षड्राशधिकेन)
 ६. विशोध्य for (विशोध्य) ७. शेषेण for (शेषे)
 ८. पिडः for (तथैव)
४३. (ङ) १. गुणिते for (गुणितं) २. शेषे for (शाखं)
 ३. खाद्युद्धते for (खाद्युद्धत)
 ४. क्रमादेयम् for (क्रमदेयम्)
 ५. विधौ for (विधौ)
 ६. पिडे for (पिडे)
 ७. मेतत् for (मेत्)
४४. (ङ) १. पिडाभावे for (पिडतवि) विकरां for (विकरां)
 २. गुणयेदाद्येन for (गुणौ यदाद्येन)
 ३. पिडकेन for (पिडके) ४. गण्यंतेतु for (यत्नम्यते)
 ५. बोद्धव्यम् for (बोद्धव्यम्)
४५. (ङ) १. चतुर्दश for (चतुर्दशे) २. विश्वैर्गुणिते for (विश्वपिडगुणितान्)
 ३. नखोद्धृते विकलाः for (मखोद्धृताद्धि कालात्)

वसुवेदयुगेति—भौमस्य—४८ । ६४ । १४० । १८४ । २२८ । २७० । ३०६ ।

३३६ । ३५६ । ३६६ । ३४२ । २६८ । १०८ । ० ।

(नोट—रेखाङ्कित अङ्क कटे हुए हैं ।)

बुधस्य—३३ । ६६ । ९८ । १२८ । १५४ । १७७ । १९४ । २०४ । २०४

। १८८ । १५७ । १०७ । ३६ । ० ॥

गुरोः—१८ । ३६ । ५० । ६६ । ७८ । ८६ । ९० । ८८ । ८४ । ७४ । ५८ ।

३६ । १६ । ० ॥

शुक्रस्य—५० । १०० । १५० । १९६ । २४६ । २९६ । ३३३ । ३३१ । ४०० ।

४१८ । ४०८ । ३४० । १५० । ० ॥

शनेः—११ । २२ । ३१ । ३८ । ४४ । ४६ । ४८ । ४६ । ४२ । ३४ । २० ।

। १६ । ६ । ० ॥

रूपगुणा ३१ वारुजिना २४५ । शर ५ । षट्पद ६६ । यम २ ।

गुणा ३ क्रमशः ॥ मध्यमभुक्तिकलाः ॥ स्फुटषट् द्वि २६ रदा

३२ वसु ८ रवेशा १७ ।

पिंडकफलन विभागो भागादि फलगृहे^३ स्वमृणं^३ तत् ।

चलकेंद्रमेषतुलादि संस्थिते कारयेत्क्रमशः ॥ ४६ ॥

वसुवेदायुगनंदाः खवेदचन्द्राः समुद्रवसुचंद्राः ।

वसुयमभलागगनाद्धृत बाह्वो रसनभो रामाः ॥ ४७ ॥

(ङ) १. २६० for (२६६) २. ३७१ for (३३१) ३. ४८ (४६)

४. ३५ for (३४) ५. २७ for (२०)

४६. (ङ) १. पिंडफल नवमभागो for (पिंडकफलनविभागो)

२. फलं for (फल) ३. ग्रहेषु वा for (गृहे)

४. स्वमृणम् for (स्वमृणंतत्)

५. चलकेंद्रे for (चलकेन्द्र) ६. मेषादौ for (मेष)

७. तुलादिके for (तुलादि)

८. 'संस्थिते' पदं लुप्त है ।

४७. (ङ) १. वसुयमयमा रसनभोरामा नन्दाग्निरामाश्च ॥ ४७ ॥

for

(वसुयमभलागगनाद्धृत बाह्वो रसनभो रामाः ॥ ४७ ॥)

वेदसुरोगोक्षगुणा रसरसरामविलोचना द्विगुणाः ।
 वसुरसयमा वसुदिशो नभस्य कुजशीघ्रपिण्डा स्युः ॥ ४८ ॥
 गुणरामाः षट्करसा वसुनंदारामलोचन शशांकाः ।
 सागर विषयशशांका नगनगचन्द्राः कृतांकभुवः ॥ ४९ ॥
 वेदनखा जलधिनखा वसुवसुचंद्रास्तुरंग विषयभुवः ।
 तुरगविशो रसरामा नभश्चपिण्डास्तशशिसूनोः ॥ ५० ॥
 द्वृस्त्रिगुणाः खशराः षड्रसा गजनगा रसाप्ती च ।
 खांका भुजंगरसवः सागर वसवः समुद्रनगाः ॥ ५१ ॥
 भुजगशरारस रामारसेदवश्चंद्रपिण्डकाः सूरेः ।
 वक्राद्विशुद्धशेषः स्फुटो भवेत्सिंहिकासूनुः ॥ ५२ ॥
 खशराः शनंखति तिथयो वसुवसुवंशः शरा विनाशत्याः ।
 शशिन वयमागुणसुराः कुनवगुणाः शून्यखांबुधयः ॥ ५३ ॥

४८. (ङ) १. मोक्षगुणा रसरसरामा विलोचनाद्विगुणाः ।

for

(वेदसुरोगोक्षगुणा रसरसराम विलोचना द्विगुणाः ।)

२. वसुवसुयमा वसुदिशो नभस्य कुजशीघ्रपिण्डाः स्युः ॥ ४८ ॥

for

वसुरसयमावसुदिशो नभस्य कुजशीघ्रपिण्डा स्युः ॥ ४८ ॥

४९. (ङ) १. गजविलोचन for (रामलोचन)

५१. (ङ) १. धृतिरसगुणाश्च for (द्वृस्त्रिगुणाः)

२. षट्क for (षड्)

३. रसाष्टी for (रसाप्ती)

४. खाङ्काश्च for (खांका)

५. भुजगवसवः for (भुजंगरसवः)

५२. (ङ) १. 'चन्द्र' पद लुप्त है ।

२. रसेन्दवः पिण्डकाः for (रसेदवश्चन्द्रपिण्डकाः)

३. चक्रा for (वक्रा)

५३. (ङ) १. शतंखतिथ्यः for (शनंखतिथियो)

२. सागरनन्देन्दवोऽङ्कजिनाः for (वसुवसुवंशः शरा विनाशत्याः)

३. गुणगुणरामाः for (शशिन वयमागुणसुराः)

४. कुनवगुणाः for (कुनवगुणाः)

कुंजरचन्द्र समुद्रागजाभ्रवेदानभो बुधिज्वलनाः ।
 गगनशिलीमुखचन्द्रा वियच्चपिंडाः सुरारिगुरौ ॥ ५४ ॥
 रुद्रायमाः कुगुणा वसुरामाः सागराम्बुनिधयश्च ।
 रसवेदागजवेगजवेदाषड्वयो लोचनांबुधयः ॥ ५५ ॥
 पंचगुणा सप्तयमा रसचंद्राः षण्णभश्च रविसूनोः ।
 अद्यतनस्वसूनयोर्ग्रहयोर्विवरं भवेद्भक्तिः ॥ ५६ ॥
 रूपगुणा बाणजिनाः शराः षडंकायमौ गुणाः क्रमशः ।
 मध्यमभुक्तिकलाः स्युरत्कृतिरदखास्तखेखरा विकलाः ॥ ५७ ॥
 मंदस्फुट खंडगुणा भुक्ति खखनवहृतागतिज्या स्यात् ।
 ग्रहवत्तत्फलविधिमृदुकेन्द्रवशाद्गतौ स्वमृणम् ॥ ५८ ॥

५४. (ङ) १. नभोऽम्बुधि for (नभोबुधि) २. गुरोः for (गुरौ)
५५. (ङ) १. द्वियमाः for (यमाः) २. कुगुणा for (कुगणा)
 ३. च for (चः) ४. वसुवेदा for (रसवेदा) ५. 'वेगज' लुप्त है ।
 ६. गजवेदाः for (गजवेगजवेदा) ७. षड्वयो for (षड्वयो)
५६. (ङ) १. पंचगुणाः for (पंचगुणा) २. षड्भश्च for (षण्णभश्च)
 ३. रूपगुणा ३१ बाणजिनाः २४५ शर ५ षण्णव ६६ यम २ गुणाः
 ३ क्रमशः ॥ ५६ ॥
 for
 (अद्यतन स्वसूनयोर्ग्रहयोर्विवरं भवेद्भक्तिः ॥ ५६ ॥)
५७. (ङ) १. मध्यमभुक्तिकलाः स्युः षड् द्वि २६ रदाः ३२ खं वसु ८ शका ११ विकलाः
 for
 (रूपगुणा बाणजिनाः शराः षडंकायमा गुणाः क्रमशः ।)
 २. मन्दगुणिताभुक्तिः खखनवहृतागतिः स्यात् ॥ ५७ ॥
 for
 (मध्यमभुक्तिकला स्युरत्कृतिरदखास्तखेखरा विकलाः ॥ ५७ ॥)
५८. (ङ) १. ग्रहवत् तन्मन्दफलं मृदु केन्द्रवशात् स्वमृणं तद्वत् च ।
 for
 (मंदस्फुट खंड गुणा भुक्ति खखनवहृतागतिज्यास्यात् ।)
 २. शीघ्रगति सङ्गुणयेदेवं शीघ्रस्य खण्डेन ॥ ५८ ॥
 for
 (ग्रहवत्तत्फलविधिमृदुकेन्द्रवशाद्गतौ स्वमृणम् ॥ ५८ ॥)

^१ न द्विहता शीघ्रगतिः संगुणाय शीघ्रभोग्यखंडेन ।
^२ खार्कैर्विभजेत्लिप्ता भौमादीनामतिशीघ्रम् ॥ ५६ ॥
^१ स्वमृणं क्रमोत्क्रमविधौ चतुर्दशो विश्वपिंडको गुणकः ।
^२ हारः ख रसागगतिरे वक्रिणोद्बोधिता चक्रम् ॥ ६० ॥
 भुक्तेरपि प्रदलिते द्वे सकलफले द्वे च कारयेद् ग्रहवत् ।
 मादंफलं त्रितयं वक्रोच्चस्य द्वितो व्यस्तम् ॥ ६१ ॥
 नवतिथयो ६२ चरषंडा विज्यावत् ॥ ६३ ॥

५६. (ङ) १. पिंडान्तरेण खार्कैः १२० लिप्ताद्यं स्यात् फलं गतेः शीघ्रम् ।

for

(नद्विहता शीघ्रगतिः संगुणाय शीघ्रभोग्य खंडेन ।)

२. स्वमृणं क्रमोत्क्रमविधौ चतुर्दश विधिश्च पिंडको गुणकः ॥ ५६ ॥

for

(खार्कैर्विभजेत्लिप्ता भौमादीनामतिशीघ्रम् ॥ ५६ ॥)

६०. (ङ) १. हरस्वगतिरेव वङ्गणात्याज्ये भुक्ते ।

for

(स्वमृणं क्रमोत्क्रमविधौ चतुर्दशो विश्वपिंडको गुणकः ।)

२. पददलिते द्वे द्वे सूकाले कारयेत् स्फुटा भुक्तिः ॥ ६० ॥

for

(हारः खरसागगतिरेवक्रिणोद्बोधिता चक्रम् ॥ ६० ॥)

नोट—(नवतिथयोविभक्ता इत्यादि आर्यापट्कं खण्डलाद्याश्चित्यम्)

६१. (ङ) १. नवतिथयो १५६ ऽष्टि १६ विभक्ताः,

पंचरसा ६५ वसु ८ हृता दश १० त्रिहृताः ।

विषुवच्छगुणिताः स्वदेशजाश्चरदलविनाडयः ॥ ६१ ॥

for

भुक्तेरपि प्रदलिते द्वे सकल फले द्वे च कारयेद् ग्रहवत् ।

मादं फलं त्रितयं वक्रोच्चस्य द्वितो व्यस्तम् ॥ ६१ ॥

(ङ) नोट—खण्डलाद्यस्य श्लोकाश्चैते ।

६२. (ङ) १. ज्या केन्द्रं स्फुटभानुं कृत्वा ये राशयश्चरार्धानि ।

भुक्तानि भोग्यगुणिताच्छेषात् खलधृतिहृतास्तुफलम् ॥ ६२ ॥

for

(नवतिथयो ॥ ६२ ॥)

६३. (ङ) गतिपादं पादोत्तां गतिं विशोऽध्यास्तकाल उदये च ।

संसारधत्तस्य तस्य ग्रहस्य चरकर्म चान्यस्य ॥ ६३ ॥

for

(चरषंडा विज्यावत् ॥ ६३ ॥)

पंचदशहीनयुक्ता ६४ क्रांतिकालाद्विरसगुणाः ॥ ६५ ॥
 त्रिज्यां विषुवच्छाया घातस्तच्छ्रुति विभाजिताश्चाप्तम् ।
 अक्षो नित्यं याम्यो गोलवशाद्दिग्भवेत्क्रांतिः ॥ ६६ ॥
 क्रांत्यक्षायुति वियोगादक्षरणपदैः शोधितैर्दिनदलाभाः ।
 भाश्रुतिकृत्योः कृतमनुयुतो नयोस्तत्पदे व्यस्ते ॥ ६७ ॥
 षड्गुणितागत शेषा नाड्यो दिवसाद्धं विभाजितात् स्यात् ।
 दिनदलकर्णगुणाप्तं तया त्रिज्यया फलं कर्णः ॥ ६८ ॥

६४. चरदल विनाडिकागति कलावधात् खखरसाग्नि ३६०० लब्धकलाः ।
 ऋणमुदयेऽस्तमये धनमुत्तरगोलेऽन्यथा याम्ये ॥ ६४ ॥

for

(पंचदशहीनयुक्ता ॥ ६४ ॥)

६५. पंचदशहीनयुक्ताश्चरार्ध नाडीभिरुत्तरे गोले ।
 याम्ये युक्त विहीना द्विसङ्ख्या रात्रिदिननाड्यः ॥ ६५ ॥

for

(क्रांतिकालाद्विरसगुणाः ॥ ६५ ॥)

६६. (ङ) १. मिश्रेष्टान्तरगुणिता भुक्तिर्दिवसे निशाद्वले प्रथमे ।
 षष्ठ्या विभज्य लब्धं विशोध्य तात्कालिको भवति ॥ ६६ ॥

for

(त्रिज्यां विषुवच्छाया घातस्तच्छ्रुति विभाजिताश्चाप्तम् ।
 अक्षो नित्यं याम्यो गोलवशाद्दिग्भवेत्क्रांतिः ॥ ६६ ॥)

६७. (ङ) १. 'क्षा' लुप्त है ।

२. दक्षपदेः for (दक्षरणपदः) ३. शोधिते for (शोधितैः)
 ४. दिनदलेभा for (दिनदलाभाः) ५. नयाकृत्वकर्षः स्यात् ॥ ६७ ॥

for

(नयोस्तत्पदे व्यस्ते ॥ ६७ ॥)
 (क्रान्त्यक्ष युति वियोगाच्चक्रपदात्शोधिते दिनदले भा ।
 भाश्रुतिकृत्योः कृतमनुयुतो नयोः कृतिरकर्षस्य ॥)

अयं पाठः साधुः

६८. (ङ) १. दिवसविभाजिता ज्यातत् for (दिवसाद्धं विभाजितात् स्यात्)

२. कर्मगुणाः for (कर्मगुणा) ३. स्वानया for (प्तातया)

४. त्रिभज्याभक्त for (त्रिज्यया)

(षड्गुणिता गतशेषा नाड्यो दिवसार्धभाजिता तज्ज्या ।

दिनदलकर्णगुणाऽप्तानया त्रिभज्या फलं कर्णः ॥ ६८ ॥) अयं पाठः साधुः

दिनदले^१ कर्णागुरो^२ त्रिज्या^३ निहते^४ श्रवणोद्धृते^५ फलस्य धनुः ।

द्युदलगुरां^६ तिथिभक्तं^७ दिनगतशेषावसः^८ क्रमशः ॥ ६६ ॥

ज्याखंडोने^९ शेषे ७० चापानयने^{१०} नवशत ७१ ।

तिथिनक्षत्र ग्रहसंक्षिप्तोत्तिस्फुटश्चैवम्^{११} ॥ ७२ ॥

दुर्जनकृतघ्न शत्रुप्रभृतीनामेषनिवदातव्यः ।

ध्यानग्रहाधिकारो जिष्णुसुतब्रह्मगुप्तकृतः ॥ ७३ ॥

आर्याः १०६३ ॥ ॥ छः ॥ इति श्री ब्रह्मगुप्त सिद्धान्तः समाप्तः ।

श्रीरस्तु ॥ छः ॥ स्वस्ति श्री संवत् १६७८ वर्षे शाके १५४४ प्रवर्त्तमाने ।

उत्तरायणे । वसंत ऋतौ । माहामङ्गलप्रदा । वंशाख शुदि १० बुधे,

समये श्री राजनगरमध्य वातव्यं.....लिखितमस्ति । स्वयं पठनार्थं ।

पठनार्थं तथा पुत्रपौत्र पठनार्थं तथा परोपकाराय । श्री कृष्णार्पणमस्तु ।

यादृशं पुस्त० । इत्यादि । भग्न द्रिष्टि । त्यादि । श्रीरस्तु ॥

इति समाप्तोऽयं ग्रन्थः ।

६६. (ङ) १. दिनदलकर्णो for (दिनदलकर्णागुरो) २. त्रिभज्यागुरो for (त्रिज्या)

३. 'निहते' पद लुप्त है ।

४. श्रवणोद्धृते for (श्रवणोद्धृते) ५. शेषावसः for (शेषावसः)

७०. (ङ) १. ज्याखण्डोने शेषे गुणिते नवभिः शतैरशुद्धहृते ।

क्षेप्पाणि शुद्धखण्डैर्गुणितानि शतानि नवचापम् ॥ ७० ॥ for

(ज्याखंडोने शेषे ॥ ७० ॥)

इति तिथिनक्षत्रदिनमाद्यादिकसिद्धौ ब्रह्मगुप्तेन ।

द्वासाप्तत्यार्याणां संक्षिप्तोत्तिस्फुटश्चैषः ॥ ७० ॥ for

(चापानयने नवशत ॥ ७१ ॥)

२. ७२ वीं संख्या का श्लोक ७३ अंकित है । अगला पृष्ठ देखिये ।

७३. (ङ) इसकी श्लोक संख्या ७२ है ।

वामपाद्वर्षे लिखितम्] प्रथम दशध्याई पत्र प्रथम लिखितम् । पश्चात् कियत्

दिवसे पंचदशाध्या इति लिखितमस्ति एवं पत्र ॥

१. प्रतिकञ्चुकारिणो for (प्रभृतीनामेष नि) २. न for (व)

३. + इति श्री ब्रह्मगुप्तकृतो ध्यानग्रहोपदेशाध्यायः समाप्तः ॥ +

अकारादिक्रमेण श्लोकानुक्रमणिका

अंशकशेषत्रियुतम्	२५२	अध्यायः पञ्चदशः	२१५
अंशकशेषा त्र्यूनाः	२३८	अध्वर्द्धाद्धि क्षेत्रान्यूडुनि	१९६
अंशकशेषेण युताः	२५२	अनयोर्न कदाचिदपि	१४९
अंशसममंशके कलासमं	२५२	अन्तरमाद्यो भूयो	१०८
अकृतार्यभटः शीघ्रगम्	२१	अन्तरयोगो तुल्यान्यदिशोः	१०५
अक्षचराद्धाज्ञाकम्	२०२	अन्त्यफलज्ययात्स्वान्य	१८४
अक्षज्याया वित्रिभलग्नात्	७९	अन्त्यानतो क्रमज्या	६२
अक्षज्या शंकुवधालम्ब	७१	अन्यत्र सर्वतोदिशम्	२७६
अक्षांशभूपरिवि	२८०	अन्या विक्षेपकला	१५०
अग्न्यष्टिभिरिषुमनुभिः	४०	अन्येष्टनाडिकाभिः कृत्वा	१३१
अग्रांत्यमुपात्त्येना	२३७	अन्यैरप्युक्तमिदं योयं	१३४
अग्राशंकुतलैक्यं	१२६	अपमेवकृतः सूर्येदु	३१९
अघनभंगालब्धम्	१७८	अपसृतिरन्यशलाका	३०६
अंगचितिविजयनंदि	१५१	अम्बरयोजनपरिविः	२८०
अंगैः रुद्रैः सिद्धैर्गजैः	३२७	अर्कफलभुक्ति घाताद्	३३
अत्र मया यन्नोक्तम्	३२१	अर्काग्राक्षकलंबकजीवे	२०८
अथवा कपालके	३१०	अर्काग्रावर्गोनं नृज्या	६७
अथवा जिनजभगणादि	२३५	अर्कद्वतरघटिका	१४७
अधिकदिनोदितघटिकाभिः	१२८	अर्कोदयास्तमययोर्विना	२६
अधिकः स्मृत्युक्तमनोरार्यं	१०	अर्कोनचन्द्रलिप्ता	३२६
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